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FIRST SESSION, FORTY-SECOND CONGRESS.

THE EXECUTIVE DOCUMENTS

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1871.

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42D CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { EX DOC. No. 11.

SUPPLIES FOR ARAPAHOE AND OTHER INDIANS.

LETTER

FROM

THE SECRETARY OF THE INTERIOR,

IN RELATION TO

An appropriation for the purpose of purchasing supplies for the Arapahoe, Cheyenne, Apache, Kiowa, and Comanche Indians.

MARCH 21, 1871.—Referred to the Committee on Appropriations and ordered to be printed

DEPARTMENT OF THE INTERIOR,
Washington, D. C., March 14, 1871.

SIR: I have the honor to transmit herewith a copy of a communication, dated the 13th instant, from the Commissioner of Indian Affairs, reporting the necessity that exists for an appropriation for the purpose of purchasing supplies for the Arapahoe, Cheyenne, Apache, Kiowa, and Comanche Indians, to enable the Department to subsist them from and after the 30th of June next.

In view of the facts stated by the Commissioner, I submit the matter to Congress, with the recommendation that the sum of $250,000 be appropriated, or so much thereof as may be necessary in furnishing said Indians with food and other necessaries of life, during the fiscal year ending the 30th June, 1872. The necessity for this appropriation is very great.

Very respectfully, your obedient servant,

C. DELANO,
Secretary.

Hon. JAS. G. BLAINE,
Speaker House of Representatives.

DEPARTMENT OF THE INTERIOR,
Office of Indian Affairs, March 13, 1871.

SIR: I have the honor to state that the appropriation made for the subsistence of the Arapahoe, Cheyenne, Apache, Kiowa, and Comanche Indians, during the second session of the Forty-first Congress, will doubtless be exhausted by the 30th of June next; and as there was no provision made for their subsistence in the last appropriation act for the current and contingent expenses of the Indian Department, and for fulfilling treaty stipulations with various Indian tribes for the year

ending June 30, 1872, and for other purposes, there will be no money at the disposal of the Department that can be used to purchase subsistence for their use for the next fiscal year, unless Congress makes an appropriation for that purpose during its present session.

Should the feeding of these Indians be stopped after the 1st of July next, they will again scatter to the plains, being compelled to do so to procure food, and the labor and expense of locating them where they now are will have been of no use or permanent benefit, either to the Government or the Indians; besides, in all probability, they will, in view of their restless condition, commit depredations which would result in another war, and cost the Government thousands of dollars where it would not cost hundreds to feed them.

In view of the foregoing, I respectfully request that the matter be submitted to Congress, with the view of having an appropriation of $250,000 made, to be used, or so much thereof as may be necessary, in furnishing said Indians with food and other necessaries of life, during the fiscal year ending June 30, 1872.

Very respectfully, your obedient servant,

E. S. PARKER,
Commissioner

Hon. C. DELANO,
Secretary of the Interior.

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42D CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { EX. DOC. No. 12.

NORTHWESTERN BOUNDARY COMMISSION.

LETTER

FROM

THE SECRETARY OF STATE,

IN RELATION TO

The expenses of a joint commission to mark the boundary line between the United States and the British possessions, from the Lake of the Woods to the Rocky Mountains.

MARCH 21, 1871.—Referred to the Committee on Foreign Affairs and ordered to be printed.

DEPARTMENT OF STATE,
Washington, March 16, 1871.

SIR: I have the honor, through you, to call the attention of the House of Representatives to the necessity of making provision for the expenses of a joint commission to mark the boundary line between the United States and the British possessions, from the Lake of the Woods to the Rocky Mountains. This subject was brought to the attention of the two houses of Congress by the President, in his annual message in December last, and a joint resolution, making the proper appropriation, passed the House, but failed, from some delay in the press of business, to obtain the concurrence of the Senate.

Circumstances connected with the relations between this Government and that of Great Britain make it desirable that this appropriation should be made with as little delay as possible; and it is therefore hoped that the matter may be acted upon, if possible, before the adjournment of your present session.

I have the honor to be, sir, your obedient servant,

HAMILTON FISH.

HON. JAMES G. BLAINE,
Speaker of the House of Representatives.

P. S.—A copy of Mr. Swann's report and of the resolution which passed the House at the last session are herewith inclosed.

IN THE HOUSE OF REPRESENTATIVES, *January* 14, 1871.

Mr. SWANN, from the Committee on Foreign Affairs, made the following report:

The Committee on Foreign Affairs, to whom was referred that portion of the President's message relating to the northwestern boundary, beg leave to report as follows:

During the spring of the past year a military commission, under Major General Sykes, United States Army, and Captain Head, was ordered by Major General Hancock

to locate the line of the forty-ninth parallel by a series of solar and lunar observations with a view to the new post and military reservation proposed to be established by the United States. This survey, fixing the international boundary, throws that line, if correct, upward of 4,600 feet north of the one hitherto recognized, and the Hudson Bay post at Pembina within the territory of the United States.

So soon as this fact was discovered, the collector of the custom-house at Pembina addressed a communication to the Secretary of the Treasury, dated June 23, 1870, asking instructions as to which of these lines should be recognized by him in the discharge of his official duties.

On the 13th day of August, 1870, the Acting Secretary of State addressed a communication to the Treasury Department, informing that Department that no joint action had been taken by the United States and Great Britain for marking upon the surface of the ground that portion of the boundary along the forty-ninth parallel which extends from the Lake of the Woods to the Rocky Mountains, and suggesting that no proceedings be adopted by the custom-house authorities which would disturb the existing condition of things on the border until the British government could be informed of the discovery which had been made by the officers of the Engineer Corps.

On the 15th of August, 1870, the Acting Secretary of State transmitted a copy of his letter to the Treasury Department to Mr. Motley, and requested him to inform the British government of the discovery which had been made by the engineer officers of the United States in regard to the true location of the boundary, as ascertained by the usual scientific method of determining such matters, which was accordingly done in a letter to Earl Granville, dated October 17, 1870.

On the 4th of November, 1870, Sir Edward Thornton, in a letter to the Acting Secretary of State, says:

"Whether the post which was erected last spring is on the forty-ninth parallel or not, can easily be verified; but in the mean time it would be very desirable that the small force now in that neighborhood should remain there for the protection of persons and the security of the mails. The only shelter, however, which they can find is in the Hudson Bay Company's fort. The governor general has therefore forwarded a request to the Canadian government that I would confer with the Secretary of State as to the expediency of allowing the boundary line which was run by Captain Pope to be considered as the boundary for the present, until the real boundary is ascertained and finally settled, so that the Hudson Bay post may be used as a shelter during the winter; for they consider that it is in the interest of the inhabitants on both sides of the line that order should be preserved on the frontier, which result can best be attained by a body of troops of both nations being stationed in its vicinity."

Such being the state of facts touching this recent discovery, the President of the United States deems it important that this part of the boundary line be definitely fixed by a joint commission of the two governments, in which this committee fully concur.

In order to facilitate the early action of Congress in disposing of this subject, a detailed estimate of the expense of a joint commission was prepared by the Bureau of Engineers, and submitted by the Secretary of War in a communication to Mr. Fish, dated November 25, 1870.

The committee recommend the adoption of the accompanying joint resolution.

IN THE HOUSE OF REPRESENTATIVES, *January* 18, 1871.

Mr. SWANN, from the Committee on Foreign Affairs, reported the following joint resolution:

JOINT RESOLUTION authorizing the President of the United States to appoint a joint commission upon the northwestern boundary.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the United States, by and with the advice and consent of the Senate, be, and he is hereby, authorized to coöperate with the government of Great Britain in the appointment of a joint commission in accordance with the plan and estimates of A. A. Humphreys, brigadier general and Chief of Engineers, submitted November twenty-three, eighteen hundred and seventy, for determining the boundary line between the United States and the British possessions between the Lake of the Woods and the Rocky Mountains, at such time as he may deem advisable.

SEC. 2. *And be it further resolved*, That one hundred thousand dollars per annum, or so much thereof as may be required, be, and the same is hereby, appropriated out of any money in the Treasury not otherwise appropriated, to carry into effect the object of said joint commission on the part of the United States and Great Britain, until the said boundary shall have been established.

42D CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { EX. DOC. No. 13.

BALANCES DUE FROM COLLECTORS OF INTERNAL REVENUE.

LETTER

FROM

THE SECRETARY OF THE TREASURY,

IN RELATION TO

Balances due from collectors of internal revenue.

MARCH 21, 1871.—Referred to the Committee of Ways and Means and ordered to be printed.

TREASURY DEPARTMENT,
Office of the Secretary, March 17, 1871.

SIR: I observe in the official report of the proceedings of the House of Representatives on Tuesday, the 14th instant, that the Hon. Mr. Morgan of Ohio introduced a resolution with a preamble, which sets forth that a resolution unanimously adopted by the House of Representatives of the Forty-first Congress, on the 13th day of December, 1870, calling upon the Secretary of the Treasury for certain information in regard to the balances due from collectors of internal revenue, had not been replied to.

I desire to inform the House of Representatives that the records of this Department show that an answer was made to the resolution on the 18th day of February last, and that the information called for, as prepared by the First Comptroller of the Treasury, was transmitted to the House of Representatives at the same time.

I have the honor to inclose a copy of my letter of the 18th of February.

Very respectfully,

GEO. S. BOUTWELL,
Secretary.

Hon. JAMES G. BLAINE,
Speaker House of Representatives, Washington, D. C.

TREASURY DEPARTMENT,
Washington, D. C., February 18, 1871.

SIR: I herewith transmit a reply to the following resolution of the House of Representatives (No. 9) adopted on the 13th of December, 1870, on motion of Mr. Winchester: "*Resolved*, That the Secretary of the Treasury be, and he is hereby, directed to furnish this House a statement of the balances due from collectors of internal revenue who are not now in office, and the total amount of the balances so due as they appear on

the books of the accounting officers of his department on the 30th day of June, 1870; that he further inform this House what amount of said balances have been paid, and in detail by whom, since the 2d day of May, 1870; the names of the collectors who have been sued on their bonds since their removal from office; with the cause of removal in each case; by what President said collectors were appointed, and by what President they were removed."

Accompanying the tabular statements prepared in the office of the First Comptroller is a letter from that officer explaining the same.

The resolution calls for the cause of the removal of each collector who has been removed, and whose name appears upon the list.

The records of this Department would, in some cases, furnish a reason for removal; but it is not possible to respond to that part of the resolution in the manner apparently contemplated.

Very respectfully,

GEO. S. BOUTWELL,
Secretary.

Hon. JAMES G. BLAINE,
Speaker House of Representatives, Washington, D. C.

O

42D CONGRESS, 1st Session. | HOUSE OF REPRESENTATIVES. | Ex. Doc. No. 14.

CONDITION OF AFFAIRS IN THE SOUTH.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

RELATIVE TO

The condition of affairs in the South.

MARCH 23, 1871.—Referred to a Select Committee of nine members to be appointed by the Speaker, and ordered to be printed.

To the Senate and House of Representatives:

A condition of affairs now exists in some of the States of the Union, rendering life and property insecure, and the carrying of the mails and the collection of the revenue dangerous. The proof that such a condition of affairs exists in some localities is now before the Senate. That the power to correct these evils is beyond the control of State authorities, I do not doubt. That the power of the Executive of the United States, acting within the limits of existing laws, is sufficient for present emergencies, is not clear.

Therefore, I urgently recommend such legislation as, in the judgment of Congress, shall effectually secure life, liberty, and property, and the enforcement of law, in all parts of the United States.

It may be expedient to provide that such law as shall be passed, in pursuance of this recommendation, shall expire at the end of the next session of Congress.

There is no other subject upon which I would recommend legislation during the present session.

U. S. GRANT.

WASHINGTON, D. C., *March* 23, 1871.

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42D CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. DOC. No. 15.

SUPERINTENDENT OF INDIAN AFFAIRS FOR MONTANA.

LETTER

FROM

THE SECRETARY OF THE INTERIOR,

IN ANSWER TO

A resolution of the House of March 14, 1871, *in relation to charges made by the late agent for the Blackfeet Indians, in the Territory of Montana, against the superintendent of Indian affairs for said Territory.*

MARCH 28, 1871.—Referred to the Committee on Indian Affairs and ordered to be printed.

DEPARTMENT OF THE INTERIOR,
Washington, D. C., March 23, 1871.

SIR: In compliance with the terms of a resolution adopted by the House of Representatives on the 14th instant, I have the honor to transmit, herewith, a copy of a report from the Commissioner of Indian Affairs, dated the 18th instant, submitting a "copy of the charges made by M. M. McCauley, late agent for the Blackfeet Indians in the Territory of Montana, against A. J. Viall, superintendent of Indian affairs for said Territory, with the reply of said Viall to said charges. Also the letter of Colonel Gibbon to Wm. Welsh, under date of February 21, relative to the distribution of annuity goods to said Indians."

I have the honor to be, very respectfully, your obedient servant,

C. DELANO,
Secretary.

Hon. JAMES G. BLAINE,
Speaker of the House of Representatives.

DEPARTMENT OF THE INTERIOR, OFFICE OF INDIAN AFFAIRS,
Washington, D. C., March 18, 1871.

SIR: I have the honor to acknowledge receipt of your letter of yesterday, inclosing a copy of a resolution adopted by the House of Representatives on the 14th instant:

That the Secretary of the Interior be requested to furnish this House with a copy of the charges made by M. M. McCauley, late agent for the Blackfeet Indians in the Territory of Montana, against A. J. Viall, superintendent of Indian affairs for said Terri-

tory, with the reply of Viall to said charges. Also the letter of Colonel Gibbon to Wm. Welsh, under date of February 21, relative to the distribution of annuity goods to said Indians, now on file in the Indian Department.

In compliance with your request, I have the honor herewith to present copies of the papers referred to in the above resolution.

Very respectfully, your obedient servant,

E. S. PARKER,
Commissioner.

Hon. C. DELANO,
Secretary of the Interior.

BLACKFEET INDIAN AGENCY, MONTANA TERRITORY,
February 13, 1871.

SIR: I write you in order to ascertain something in regard to the conduct of the superintendent of Indian affairs of this Territory.

On the 19th day of October last I arrived here and took charge of this agency. I found upon my arrival a small amount of Indian provisions, left by the retiring agent. I immediately made a requisition on Superintendent Viall for what I thought would be necessary for the winter supplies at this agency. I received a reply that my requisition would be honored as soon as possible. The articles not coming, I again wrote the superintendent, and received the same reply. From that time to this nothing has been furnished this agency by the superintendent—not even to a bottle of Thompson's eye-water, which I requested him to send me for the use of sore-eyed Indians. On the 9th day of December last I received at this agency five and one-half tons of Indian goods, valued, as per invoice, at $7,620 04. These goods consist of blankets, clothing, and hardware, for the Indians. These goods were furnished, I believe, by Mr. L. M. Black, but am not positive, as I never receipted for them to any one, except to sign the bills of lading of the wagon-train. These are all the goods received by me. These goods arrived here during my absence, and the wagon-master that brought them told my employés that "Mr. Garrison (the owner of the train) had received from Mr. L. M. Black one-half of the freight money on fifty tons of annuity goods from Corinne, Utah Territory, to this agency;" and further said, that if I did not receipt to Black for the full amount, I would lose my head.

On or about the 25th of November last I received a letter from Superintendent Viall dated "Bozeman, Montana Territory, November 23," requesting me to be in Helena by the 1st of December, "before *parties* left for Washington;" in response to which letter I hastened to Helena. On the 2d day of December Superintendent Viall requested me to accompany Mr. Black to his (Black's) hotel, as he (Black) had business with me. Upon arriving at the hotel, and while in Mr. Black's room, he (Black) first asked me if General Sully had ever purchased anything out of the $50,000 appropriation for this agency for 1870. I answered him I did not know. He then requested me to make out and sign vouchers in his (Black's) favor to the amount of forty-five thousand dollars for goods received at this agency. This I refused to do, and informed him (Black) that I would receipt for what goods came to this agency and no more. He then said that if I would sign said vouchers, Superintendent Viall would indorse them. I refused. He (Black) further said, that if I would sign such vouchers I should stay in office (as agent) as long as Grant was President, as he (Black) and Commissioner Parker were great friends.

On the next day (3d December) Superintendent Viall sent me twice to the hotel, (once in company with Black, and once by myself,) saying that "Black had business with me." Upon arriving at the hotel Mr. Black made the same request in regard to signing vouchers, which I again refused to sign, and never have signed. The five and one-half tons of goods mentioned arrived at agency while I was absent, as stated, but I returned in time to receive them.

On the 23d of January, 1871, a man by the name of Simmons—A. J.—arrived at this agency, with several employés, and demanded that I should turn over to him this agency, the Government property, &c., on the strength of an order from Superintendent Viall, which he had to that effect. I at first concluded to do so *under protest*, but upon further reflection I concluded that inasmuch as I was, and am, a commissioned officer, appointed to this agency, under bonds to the Government, and that I had never been officially notified of my removal or the appointment of my successor, I would not be justified in turning over the property to Mr. A. J. Simmons, nor any one else, except to my duly qualified successor in office. At this time several lodges of Piegans where here awaiting their annuities. In conversation with Mr. Simmons, and before

I had refused to turn over to him, he informed me that it was his intention to give each Indian one blanket, and send them buffalo hunting.

On the 25th of January, 1871, Mr. Simmons made his demand in writing, which demand I also refused in writing. On the 28th of January I made a distribution of a portion of the goods to the Indians, in the presence of two commissioned officers of the United States Army, who were sent here at my request by the commanding officer at Fort Shaw, forty miles from here. These officers were here as witnesses to the distribution, and have signed their names as such to the proper papers, and have ere this made their own report of the affair.

Some days since a large amount of provisions was sent from Helena, Montana Territory, destined for the Indians of this agency, as I am informed. These goods were stopped and stored (as I am also informed) by this same Mr. Simmons, at Sun River Crossing, forty miles from here.

From thirty to forty lodges of Piegan and Blood Indians will be in here to-morrow. Two of the head chiefs are already here, and are in the room as I write this. I have nothing for them but a little corn and flour, and the little that is left of the five and one-half tons of goods before spoken of, the larger portion of which was issued on the 28th.

The main camp is but a few days behind. These Indians have traveled from two hundred to three hundred miles to get here, in the midst of winter, and now find that their provisions are held by a stranger forty miles away.

The foregoing facts I stand ready to substantiate by affidavit.

Very respectfully,

M. M. McCAULEY,
United States Indian Agent for Blackfeet.

Hon. E. S. PARKER,
Commissioner Indian Affairs.

WASHINGTON, D. C., *February* 28, 1871.

SIR: I have the honor to acknowledge the receipt of your communication of this day, inclosing a copy of a letter from Mr. McCauley, late agent for the Blackfeet Indians, in which letter certain charges or allegations are made against myself and the management of Indian affairs in the Montana superintendency.

Mr. McCauley states, 1st, that he received five and one-half tons of Indian goods, valued as per invoice at $7,620 04, furnished, as he believed, by Mr. L. M. Black; that they were all the goods received, and that Mr. Garrison, the owner of the freight train, told his (McCauley's) employés that Black had paid to Mr. Garrison one-half of the freight money on fifty tons of annuity goods from Corinne, Utah Territory, to said agency, and that if he, McCauley, did not receipt for the full amount he would lose his head, &c.

In regard to this matter I would say that the records of the Indian Office will show that only five and one-half tons, or thereabout, of annuity goods were purchased for the Indians at said agency, and consequently that the statement made by Garrison, if made, was wholly unwarranted and without any foundation whatever. In view, therefore, of the fact that there was no foundation for the statement reported to have been made by Mr. Garrison, I respectfully submit that Mr. McCauley has been imposed upon by his employés, or that the statement has been manufactured or concocted by Mr. McCauley himself for the purpose of furthering or accomplishing some object he has or may have in view. In fact, from the general character sustained by him in Montana, I have no hesitancy in saying that, in my opinion, the statement emanated from him, and that Mr. Garrison never made any such statement.

Regarding McCauley's statement about his having received a letter from me to come to Helena, and to the conversation he says he had with me relative to Mr. Black, I have to say that no such letter was ever written by me, nor did the conversation referred to ever take place. As to the interview he claims to have had with Mr. Black, I have no knowledge, but I am of the opinion, from my knowledge of the two men, that there is not a word of truth in the statement of McCauley.

Relative to Mr. Simmons having stored goods purchased for the Blackfeet agency at Sun River crossing, I would say that no instructions were given for the storing of said goods at that place; yet, in view of the fact that McCauley's appointment had been revoked, I think Mr. Simmons was justified in not delivering the supplies at the agency, when McCauley would doubtless have gotten possession of them.

I hold myself responsible for the supplies referred to, and will see that they are properly disposed of so soon as the newly-appointed agent for the Blackfeet Indians shall have taken charge of the agency.

I conclusion I would say that there is only one statement made by McCauley in reference to myself that is true, and that is in regard to the one bottle of Thompson's eye-

water, which he says he requested me to send to him; I believe he did make such request, but I did not send it; nor did I send him the other articles or supplies referred to, for reasons well known to the Department.

Very respectfully, your obedient servant,

J. A. VIALL.
Superintendent Indians, Montana.

Hon. E. S. PARKER,
Commissioner of Indian Affairs.

WASHINGTON, D. C., DEPARTMENT OF THE INTERIOR,
BOARD OF INDIAN COMMISSIONERS,
March 8, 1871.

SIR: I inclose herewith for your information a copy of a letter received this morning per hands of William Welsh, from Colonel Gibbons, commanding Fort Shaw, Montana Territory, concerning the present condition of the Piegan Indians, and an account of his witnessing the issuing of annuity goods to the Indians, and the satisfaction with which they expressed themselves concerning the quality of the goods distributed, &c.

Very respectfully, your obedient servant,

VINCENT COLYER, *Secretary.*

Hon. COLUMBUS DELANO,
Secretary of the Interior.

FORT SHAW, MONTANA TERRITORY,
February 21, 1871.

DEAR SIR: I was called on a few days ago to send an officer to the Blackfeet agency, about thirty-six miles northwest of this post, to witness the distribution of goods to the Indians. I accompanied the officer to the agency, and found assembled there some six hundred Indians, men, women, and children, principally of the Piegan and Blood tribes of the Blackfeet nation.

The chiefs present were: 1. Big Lake, principal chief of Piegans; 2. Mountain Chief, Piegan; 3. Bird Chief, Piegan; 4. Generous Woman, Piegan; 5. Five Bears, Piegan; 6. Middle Bull, Piegan; 7. Many Horses, Piegan; 8. Bear Chief, Piegan; 9. Screaming Owl, Piegan; 10. Elk Chief, Piegan, blind; 11. Fish Child, Blackfeet, living with Piegans.

I was invited to meet the chiefs in the inevitable "talk," and never heard Indians talk more peaceably.

Mountain Chief spoke first. He is an old man, and said to be very smart. His was one of the bands Colonel Baker was after last winter, but did not succeed in striking. He expressed a desire to live at peace with the white man, and to have no more trouble, and was glad to meet us in this way.

Bird Chief, an old man, who was in the fight with Colonel Baker last year, said he had not had a good night's sleep since that fight, and had ever since been moving from place to place, expecting every day to be attacked by somebody, he did not know who; that they all wished to live at peace with the whites now, and to have no more trouble. A number of others spoke, all in the same strain. They all expressed pleasure at having an agent residing among them, as Major McCauley now was; that heretofore their agent never lived at the agency, but would sometimes appear there for a day or two, promising to meet them elsewhere, but when they went there he was always somewhere else, and he failed to keep his promises with them. (I suspect this is true, and their present agent certainly deserves credit for taking up his residence in such a desolate, uninviting region as that surrounding the agency.) They all expressed themselves satisfied with their present agent; said he had done more for them than any previous agent, and hoped he would remain. That I would be surprised if I could compare the present issue of goods, with which they seemed very much pleased, with issues by former agents, when each Indian would receive a little package which he could carry away in his hand.

They hailed this new state of affairs as a good sign, and that now white men should always go through their country in safety, and if any of their horses should be stolen they should be returned at once.

I told them I was glad to hear such "good words" from them; that it was better for both whites and reds to be at peace than at war, and that I knew the President preferred peace to war with them; that the Indians knew there were bad as well as good whites, and the whites knew there were both good and bad Indians; that there were a great many good whites who were now trying to do all the good they could to help the red

man, and that they would, and expected all good Indians to do all in their power to assist in bringing about a better state of feeling between the Indians and the whites, so there would be no more trouble, and I promised to send their "good words," so that they would reach the ear of the President. I know of no more effectual method of fulfilling this promise than through yourself.

Peace with this heretofore troublesome band—the Piegans—is much to be desired, and I think can be maintained without much trouble, provided they are dealt with justly, and the intentions of the Government toward them are honestly carried out.

The agent complains that of the $50,000 appropriated for these Indians, but $7,000 worth of goods has been sent him for distribution, and that very few provisions have been sent.

The Indians presented the appearance of being very destitute, and although they have plenty of buffalo meat to eat, *this is all* they have got; and breadstuffs, some sugar and coffee, &c., would be very acceptable.

Unfortunately their chiefs have not as much influence as is desirable, and therefore we should endeavor "to hold up their hands," like those of Moses of old, as much as possible, by conciliating them as much as possible, and demonstrating to the younger men of the tribe that the favor of the Government is worth contending. The agent says he never saw a more peaceably disposed set of Indians, and my observation confirms this. It is to be hoped that this disposition will continue.

The Pend d'Oreilles, occupying a reservation directly opposite, on the western side of the Rocky Mountains, are at present at war with the Blackfeet, and no longer ago than last fall stole about two hundred of their horses.

The chiefs I saw at the agency expressed a desire to make peace with the Pend d'Oreilles, and it is very desirable that such a peace should be brought about. It might be done, I think, by instructions sent to the agents of the two tribes.

During the council Elk Chief, who was totally blind, made a speech to the young men, urging them to act in accordance with the promises made by their chiefs; that it was no use to talk without acting; that he, being blind, could do nothing, but that every one should do all he could to fulfill in good faith the promises there made for the tribe, so that the whites and reds should live together in peace.

The Indians all seemed highly pleased at their visit to the agency and the presents received, and yesterday morning left for their camps north on the Maria River.

A visit to this section of country by some of the gentlemen who have interested themselves in Indian affairs could not but be productive of good.

Very respectfully, yours,

JOHN GIBBON.

Mr. WM. WELSH,
1122 *Spruce Street, Philadelphia, Pennsylvania.*

42D CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. DOC. No. 16.

ROBERT C. SCHENCK.

LETTER

FROM

THE SECRETARY OF STATE,

IN RELATION TO

The compensation of Robert C. Schenck, United States minister to Great Britain.

APRIL 5, 1871.—Ordered to be printed.

DEPARTMENT OF STATE,
Washington, April 5, 1871.

SIR: The statute of 1856 (vol. xi, chapter cxxvii, page 55, Statutes at Large) provides that a diplomatic representative of the United States may receive compensation for a time not exceeding thirty days while waiting to receive instructions. After that time no compensation can be paid to such officer until he actually leaves for his post.

The statute of 1852 (vol. ix, chapter cix, page 100, Statutes at Large) provides that no officer shall receive compensation for discharging the duties of another office.

General Schenck, when about to proceed to his post, and while waiting here for instructions, was directed by the President to remain in Washington to act as one of the American commissioners in the Joint High Commission now sitting in Washington.

The labors of General Schenck in this service are, to say the least, quite as onerous and his duties quite as responsible as they would be had he proceeded to London. But for the proposal of the British Government to organize the commission, he would have been charged with these duties in London; and yet it is impossible, under the existing laws, to render him the compensation for them, to which he is justly entitled. Under these circumstances I venture to suggest that justice to him calls for such action of Congress as will either enable the Treasury Department to continue the payment of his salary while detained here, or allow him to be paid, for his services as commissioner, from the appropriation already made by Congress.

I have the honor to be, sir, your obedient servant,

HAMILTON FISH.

Hon. JAMES G. BLAINE,
Speaker of the House of Representatives.

A BILL in relation to the compensation of the United States minister to Great Britain.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the accounting officers of the Treasury be authorized and directed to pay to Robert C. Schenck, out of any money appropriated for the compensation of an envoy extraordinary and minister plenipotentiary to Great Britain, his salary as such minister up to the time when he shall reach his post, notwithstanding his detention in the United States to serve as one of the members of a joint commission, beyond the thirty days allowed by the eighth section of the "Act to regulate the diplomatic and consular systems of the United States," approved August eighteen, one thousand eight hundred and fifty-six; but no pay to be made him for his services as such commissioner.

42D CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { EX. DOC. No. 17.

JAPANESE PUPILS TO WEST POINT.

LETTER

FROM

THE SECRETARY OF STATE,

SUBMITTING

The draught of a bill for admitting six Japanese pupils to West Point Military Academy, and recommending the passage of the same.

APRIL 11, 1871.—Referred to the Committee on Foreign Affairs and ordered to be printed.

DEPARTMENT OF STATE,
Washington, April 3, 1871.

SIR: I have the honor to inform you that the charge d'affaires of the empire of Japan has unofficially made known to me the desire of his government to send some pupils to West Point on the same terms and in the same manner that they have been admitted to the Naval Academy.

It is hoped that Congress will authorize the Secretary of War to comply with the wishes of the Japanese government.

For your convenience, I submit a draught of a bill on the subject, similar in its provisions to the joint resolution approved July 27, 1868, by which such pupils were admitted to the Naval Academy.

I have the honor to be, sir, your obedient servant,

HAMILTON FISH.

Hon. JAMES G. BLAINE,
Speaker of the House of Representatives.

Inclosure: Draught of bill for admitting six Japanese pupils to West Point Military Academy.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized to receive for instruction at the Military Academy at West Point not exceeding six persons, to be designated by the government of the empire of Japan: *Provided*, That no expense shall thereby accrue to the United States: *And provided further*, That the Secretary of War may, in the case of the said persons, modify or dispense with any provisions of the rules and regulations of the said Academy, the enforcement of which circumstances may, in his opinion, render unnecessary or undesirable.

42D CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. DOC. No. 18.

OCCUPATION OF ROME BY THE KING OF ITALY.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

IN ANSWER TO

A resolution of the House of the 31st ultimo, relative to the occupation of Rome by the King of Italy.

APRIL 13, 1871.—Referred to the Committee on Foreign Affairs and ordered to be printed.

To the House of Representatives:

I transmit to the House of Representatives, in answer to their resolution of March 31, 1871, a report from the Secretary of State, with accompanying documents.

U. S. GRANT.

WASHINGTON, *April* 11, 1871.

DEPARTMENT OF STATE,
Washington, April 11, 1871.

The Secretary of State has received from the House of Representatives a resolution adopted on the 31st ultimo, which is in the following words:

Resolved, That the Secretary of State be requested (if not incompatible with the public interests) to communicate to this House copies of any correspondence between the State Department and our minister plenipotentiary in Florence in relation to the occupation of Rome by the King of Italy; and also what correspondence has taken place since December 1, 1870.

And in reply has the honor to lay before the President extracts from four dispatches addressed to this Department by the minister of the United States at Florence, which appear to be all the unpublished correspondence called for by the resolution.

Respectfully submitted.

HAMILTON FISH.

The PRESIDENT.

List of accompanying papers.

No. 1. Mr. Marsh to Mr. Fish, No. 321, November 18, 1870.
No. 2. Mr. Marsh to Mr. Fish, No. 323, November 23, 1870.
No. 3. Mr. Marsh to Mr. Fish, No. 327, December 29, 1870.
No. 4. Mr. Marsh to Mr. Fish, No. 328, January 3, 1871.

No. 1.

Mr. Marsh to Mr. Fish.

[Extract.]

No. 321.] LEGATION OF THE UNITED STATES,
Florence, November 18, 1870. (Received December 7.)

SIR: The King of Italy, who had been spending some time in Piedmont and Lombardy, returned to Florence at the close of the last week. During his absence the ministry had decided that his Majesty should make a formal entry into the city of Rome on the 30th of November, and this determination was publicly announced, and preparation for the reception of the King and court at Rome was commenced. It was understood at the time of this announcement that the arrangement was made with the assent of the King; but soon after his return to this city it was rumored that the intended visit to Rome would not take place at present; and it appears to be now settled that his Majesty will not enter that city until Parliament shall have accepted the *plebiscite* of the Roman people, and adopted the laws which the ministry shall propose for guaranteeing to the Papacy such privileges and franchises as it is deemed expedient to secure to it. * * * *

In fact, for the moment, it is difficult to conjecture the possible consequences of this state of things; but in any case, I think public opinion will not tolerate a retrograde policy on the subject.

GEORGE P. MARSH.

No. 2.

Mr. Marsh to Mr. Fish.

[Extract.]

No. 323.] LEGATION OF THE UNITED STATES,
Florence, November 23, 1870. (Received December 12.)

SIR: * * * * * *

It is now formally announced that the King and court will go to Rome about the beginning of the new year, and I think the entrance of his Majesty into that city will not again be postponed.

GEORGE P. MARSH.

No. 3.

Mr. Marsh to Mr. Fish.

[Extract.]

No. 327.] LEGATION OF THE UNITED STATES,
Florence, December 29, 1870. (Received January 21.)

SIR: The Chamber of Deputies of the Italian Parliament adjourned a few days since to the 16th of January, after passing a resolution for the acceptance of the Roman *plebiscite* of annexation, and a bill providing for the removal of the seat of government to Rome on the 30th of June, 1871. The former of these measures encountered strong opposition in the senate, which remained in session some days after the adjournment of the chamber, but it was finally adopted by a considerable majority. The ministry then asked the passage of the bill from the

chamber for the transfer of the capital, but the senate was indisposed to take the subject into consideration, until a bill pending in the chamber and now in the hands of a committee, for settling the prerogatives and guarantees to be conceded to the Pope, should have been passed by the lower house, and it has now adjourned without further action on the question.

The senate is a much more conservative body than the chamber, and will, I think, insist on going to quite as great lengths in the way of concession to the Papacy as the government has ever proposed. I do not think the chamber will have firmness enough to risk the defeat of the project of removal of the capital, by refusing to grant extravagant privileges to the Pope, and the consequence will probably be that the Crown and the nation will be legally placed in an attitude toward the Papacy wholly inconsistent with their dignity and independence.

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GEORGE P. MARSH.

No. 4.

Mr. Marsh to Mr. Fish.

[Extract.]

No. 328.] LEGATION OF THE UNITED STATES,
Florence, January 3, 1871. (Received January 23.)

SIR: In compliance with the urgent request of the leading citizens, and the well-known wishes of the people of Rome, it was officially announced that the King of Italy would pay a formal visit to that city near the close of the month of December last, but for reasons which have not been made public the day appointed for that purpose was changed, and the 10th of the present month was fixed for the solemn entry of his Majesty into the new capital of the kingdom.

On the 30th of December the diplomatic corps was notified that the usual New Year's reception of his Majesty, which had been appointed for the 31st of December, would not take place on that day, and the evening paper announced that the King had left Florence for Rome on the afternoon of the 30th, in order to encourage by his presence and direct the efforts of the public authorities to diminish the evils resulting from the inundation of the Tiber, which had overflowed its banks, risen to an almost unprecedented height, and covered with water a large part of the town and an extensive district of the Campagna in the vicinity of the city.

The King reached Rome on the morning of the 31st December, and after a stay of ten or twelve hours returned to Florence. He was very well received by the municipality and the people, but the suddenness of his arrival and the shortness of his stay prevented the manifestations of satisfaction and loyalty which had been in part arranged for his formal entry. His Majesty, in a letter not yet published, announced his arrival to the Pope, and, as it is said, intimated that his visit would not be long enough to allow of an interview between the Pontiff and himself. It is believed that the Pope made no reply to his Majesty's letter at the time, and it is not known that any answer has been since received.

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GEORGE P. MARSH.

42D CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. DOC. No. 19.

FINAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY

OF

NEBRASKA

AND PORTIONS OF

THE ADJACENT TERRITORIES,

MADE UNDER THE DIRECTION OF

THE COMMISSIONER OF THE GENERAL LAND OFFICE.

BY

F. V. HAYDEN,
UNITED STATES GEOLOGIST.

MARCH 23, 1871.—Ordered to be printed.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1871.

LETTER TO THE COMMISSIONER.

WASHINGTON, D. C., *March* 1, 1868.

SIR: I have the honor to transmit my final report of the United States Geological Survey of Nebraska and adjacent Territories.* The observations here recorded were made with some care at the time, and, inasmuch as they will not probably be repeated for years to come, may prove of value to the state. The history of the origin and purposes of the survey have been so clearly set forth in your annual report of the General Land Office for 1867, that I beg permission to introduce it in this connection:

In the second section of the act of Congress, approved March 2, 1867, making appropriations and to supply deficiencies, it is declared "that the unexpended balances of the appropriations heretofore made for defraying the expenses of the legislative assembly to the Territory of Nebraska, shall be diverted and set aside for the purpose of procuring a geological survey of Nebraska, to be prosecuted under the direction of the Commissioner of the General Land Office."

It has been estimated that the unexpended balance applicable to the geological survey is $5,000. Under that authority Dr. F. V. Hayden was appointed on the 29th April, 1867, to make a geological examination and survey, with compensation of $2,000 per annum. With the limited means provided, he was allowed an assistant geologist and paleontologist, at the rate of $1,000; three collectors and laborers at not exceeding $700, the sum of $300 having been set apart for chemistry and natural history; while the sum of $1,000, or the residue of the means, was designed for general expenses of outfit and incidentals in the service, which was restricted to one year from the date of the appointment.

The geologist was directed to proceed as soon as necessary arrangements could be made to the sphere of his operations. He was instructed to ascertain the order of succession, arrangement, relative position, dip, and comparative thickness of the several strata and geological formations in the State, to search for and examine all the beds, veins, and other deposits of ores, coals, clays, marls, peat, and other like mineral substances, as well as the fossil remains of the various formations; to obtain chemical analyses of such of those substances, and of the different varieties of soil, whereof it may be deemed desirable to ascertain the elementary constituents. He was required also to determine by careful barometrical observations the relative elevations and depressions of the different parts of the State of Nebraska, and to gather in the field of his explorations collections in geology, mineralogy, and paleontology, to illustrate the notes taken in the field. In order to enable the Commissioner to present to Congress the results of the geological survey, it was stipulated that a preliminary report should be made of the progress of the work, accompanied by such maps, sections, and drawings as might be considered requisite to illustrate the report, it having been ordered that the final report under the appropriation should embody the results of the entire survey, and be accompanied by a geological map, with carefully-prepared sections and diagrams, showing by different colors and other marks and characters the principal

* It is but just to me to be permitted to state that this report was completed in its present condition three years ago, and the manuscript delivered to the Commissioner. It is now printed without any opportunity for revision. Several chapters which have appeared in other publications are omitted.

localities and geographical range of the various geological formations of the district explored, and by drawings and descriptions of the characteristic fossil remains of the different groups of strata—advance data having been called for at short intervals, in order that the Department might know the progress of the work.

It was required in our instructions that the region of Nebraska south of the Platte River should be first examined, it being occupied by the limestones of the true coal measures, and that a careful search should be instituted for the localities, depths, and extent of deposits of that most valuable mineral. It was deemed important to extend the explorations and examinations along the Missouri to Sioux City, as it had been reported that there was a bed of coal outcropping from rocks of the chalk formation near the Omaha reserve, then under survey for the accommodation of the Omaha and Winnebago Indians. It was desired that the geologist, who was furnished with a map of public surveys, should locate geological formations by townships and ranges of the sixth or governing principal meridian in Nebraska. As the unsurveyed region also includes settled portions of the State, it was required that the explorations should also be there directed to determine the location and extent of natural resources in coal, metallic ores, hydraulic and common limestone, fire-clays, freestone, flagstone, and marbles, properly belonging to the various formations there existing, and which would be of immediate use to the people. As the predominating interest in the State is farming, his attention was directed to the examination of its soils and subsoils, to their adaptability to particular crops, as well as to the best method of preserving and increasing their fertility.

Information was also called for in regard to the introduction of suitable forest trees, in order to promote the growth of timber.

* * * * * * * * *

Attention should likewise be given to the materials for the construction of roads, houses, bridges, such as building stones, limestones for the manufacture of quick-lime, sand, clays for making bricks and tiles, as well as for potters' use. Particular attention should be given to the various soils and subsoils, and their adaptability to the growth of different kinds of crops, fruit and ornamental as well as forest trees. If the district is hilly or mountainous, barometrical observations should be made to determine the heights of the elevations above the sea and the principal streams, and attention should likewise be given to the climatology of the country. Full sets of collections of all the different kinds of rocks, soils, ores, minerals, and mineral waters of every description, as well as of the various organic remains characterizing the different formations, should be carefully collected and preserved for study and analysis. These collections to be arranged and permanently preserved in the Department. It is proposed that specimens of every kind be transported to the Department for careful investigation, in order that final and more detailed reports may be made out, illustrated by maps, sections, diagrams, and drawings of the various fossil remains, characteristic of the different rocks.

Authority should be given for the publication of the final reports in a suitable form, and in such manner as to be creditable to the country. A few such reports, properly prepared by competent and reliable authorities, with full statistics of our resources, would, if distributed abroad, have a tendency to stimulate immigration, and cause the rapid settlement of our vast unoccupied public domain, thus increasing the national wealth and power, and relieving the burdens of general taxation.

In accordance with your instructions, the survey was prosecuted with all the energy in my power, and I was enabled during the season to examine the entire eastern portion of the State, and some portions farther west. Mr. F. B. Meek, the very able paleontologist of the survey, passed through the State of Iowa, from the Mississippi at Iowa City to the Missouri at Nebraska City, in company with Mr. C. A. White, the State geologist of Iowa, in order that he might connect the geological formations of that State with those of Nebraska, and also trace out the coal-

beds in their western extension. His report, herewith transmitted, will show the success and thoroughness with which he performed his labors.

The entire area of the State of Nebraska belongs to what is called the plain or prairie country of the West. The strata are entirely horizontal, and are seldom exposed to the scrutiny of the geologist, except along the banks of streams. The greater portion of the State is covered with a great thickness of yellow marl, which oftentimes conceals the underlying formations, but it gives to the soil the wonderful and inexhaustible fertility which the entire eastern portion possesses. As an agricultural and grazing State Nebraska must eventually take a very high rank.

Nebraska, the youngest State in the American Union, extends from the Missouri westward to the Rocky Mountains, with an extreme length of 412 miles, decreasing to 310 miles on the southern border, its extreme width being 208 miles, diminishing to 138 miles on the west. Its area is 75,905 square miles, or 48,636,800 acres.—(Report Commissioner General Land Office, 1867.)

But three of the principal geological formations are represented in the State, Carboniferous, Cretaceous, and Tertiary. Of the Carboniferous strata only the upper members occur, and these seem to thin out in their western extension, until they almost disappear in the region of the Rocky Mountains.

Much attention was given to the study of the coal-beds in the southeastern portion of the State, and the conclusion was reached that no coal-beds would be found more than from 12 to 30 inches in thickness. In a country which is so destitute of timber these beds may be wrought with advantage. The subject of tree-planting in Nebraska cannot be too strongly impressed upon the settlers in that State. No labor or expense should be spared and no delay permitted in this direction. Not many years will elapse before fine forests of young timber will cover much of this fertile region. The influence of these forests upon the climate and the soil has been discussed in the report. A careful examination of the geological formations, and the physical geography of the State, will show at once that its mineral resources must be very limited. No ranges of mountains come within its borders. Some iron ores occur, but there is not sufficient fuel to utilize them. Gold and silver in paying quantities will not probably be found.

The supply of building material has been shown to be inexhaustible, and the skill and industry of the inhabitants is now fast turning it to practical use.

The Union Pacific Railroad, passing directly across the State from east to west, has given a wonderful impulse to its material prosperity, and must continue to do so for all time to come. The demand for branch roads in every direction has already been made by successful agriculture, and the ease with which they can be built, especially along the bottoms of streams, is quite remarkable.

With the exception of the Missouri River, there are no navigable streams in Nebraska. The Platte, although very broad, is always too

shallow, is full of sand-bars, and quicksands, and at certain seasons of the year it is nearly dry. The supply of water for milling and manufacturing purposes, however, seems to be abundant. In conclusion I would say that my examination of the resources of the State has greatly increased my already favorable impression in regard to them. With its broad, fertile bottoms bordering a navigable river like the Missouri for over three hundred miles; with the rich soil of the uplands, and their almost unlimited supply of all the agricultural productions adapted to that climate; with its railroads, water privileges, and the marked energy and industry of its inhabitants, Nebraska is certainly destined to take a high position among the States of our Union.

It remains now for me to acknowledge my indebtedness to many friends, for aid and sympathy during the progress of the survey. The appropriation was so small that it would have been impossible for me to have brought the survey to a successful termination without the generous assistance of the United States military authorities. Armed with a letter from General Grant to the military commanders in the West, requesting them to afford me all the aid in their power not inconsistent with the public service, I was everywhere received by them with the utmost courtesy. General William Myers, chief quartermaster Department of the Platte, supplied me with a complete outfit for traveling, horses, equipments, &c.; General Barriger, the chief commissary, supplied me with commissary stores at officers' prices. From Colonel E. B. Carling, at Fort D. A. Russell, I obtained an outfit, which enabled me to make an examination of the coal-fields along the base of the Rocky Mountains, near the close of the season. To the citizens of Nebraska, and the press generally, I am indebted for the most cordial sympathy and aid, and the mere list of their names would occupy pages of this report. The officers of the Union Pacific Railroad supplied me with every facility in their power, as well as free transportation for party and freight along the road.

To the Hon. P. W. Hitchcock, representative of the Territory in Congress, the people of Nebraska are indebted for the appropriation which enabled the Geologist to make the survey. I wish to express my obligations for many favors of great value to Dr. G. L. Miller, Captain William Wilcox, and Hon. A. S. Paddock of Omaha.

The reports of F. B. Meek, paleontologist, and Mr. S. H. Scudder, on certain insects, injurious to vegetation, are of the highest value. The report of Mr. Scudder was prepared without any expense to the Government.

I take pleasure in extending my cordial thanks to my assistants in the field, Mr. James Stevenson and Edward Chase, who labored with zeal to advance the interests of the survey.

Very respectfully, your obedient servant,

F. V. HAYDEN,

United States Geologist.

To the *Commissioner General Land Office, Washington, D. C.*

REPORT.

CHAPTER I.

DETAILED REPORT OF DOUGLAS AND SARPY COUNTIES.

Detailed reports of counties must necessarily be attended with more or less repetition. Yet in presenting a report on the geology of a State it would appear to be important to the inhabitants of each county that the local geology be dwelt upon with as much minuteness as possible. It is for this reason that I have called this portion of the report the local geology, much of which will no doubt be more interesting to the inhabitants of the State than the general geology. I will, therefore, commence with Douglas and Sarpy Counties. The basis rocks of these two counties are for the most part of the age of the Upper Coal-Measures.

If the Permo-Carboniferous and the Permian were ever deposited over this area, they were swept away by erosion prior to the deposition of the Cretaceous rocks. If we follow the valley of the Platte westward on the northern side, we shall see the junction of the two great periods, Carboniferous and Cretaceous, and we shall find that the beds of the Dakota Group, or what we suppose to be the Lower Cretaceous beds of the West rest directly down on the limestones of the Upper Coal-Measures. As an illustration of this statement, we find near the Old Otoe Village, eight miles above the mouth of the Platte, a good exposure of the sandstone resting conformably on the Carboniferous limestone.

In Douglas County there are very few exposures of the underlying rocks. Indeed, the only quarries of any importance in the county are near Omaha, on the Missouri River. But along the Platte the limestones jut out in massive beds, which supply all that region with excellent building stone, and most of that used in Omaha is transported from these quarries. The exposure of limestones near Omaha is not great, only about eight or ten feet above the water's edge, and over these limestones there are from 150 to 200 feet of drift and yellow marl, which must be stripped off before the rocky layers below can be made available. These difficulties will always render this quarry an expensive one. These limestones have also been seen in one or two localities farther up the river. At Rockport, about ten miles above Omaha, they form the bed of the river, and on this account this locality was formerly known as Rock Bottom, and attracted the attention of railroad engineers as a suitable crossing for a line of road. I was also informed that at low water, limestones are seen at Fort Calhoun and DeSoto, and it is probable that at the latter locality, the Carboniferous beds disappear beneath the river, not to be seen again in the valley of the Missouri, until disclosed by the uplifting of the Rocky Mountain ranges. Passing westward from Omaha there is no important exposure of rocky beds to be observed. The scenery is very monotonous—a rolling prairie, with scarcely a tree to be seen.

Near Bellevue, Sarpy County, there is an exposure of the Upper Coal-Measure rocks at low water, a very careful section of which has been given in Mr. Meek's report. This quarry has been wrought more or less

for years, and the limestones used for building purposes, and burned into lime. But the most important quarry in this country north of the Platte is that belonging to Mr. Watson, and located on the Pappillion, three miles west of Bellevue. This quarry has been worked for many years, and contains several layers of valuable rocks for building purposes. It is a source of considerable revenue to the owners, and the materials are taken to Bellevue and Omaha in great quantities, where a ready market is found. The following is a section of the beds in descending order:

6. Vegetable soil, two to four feet thick, with a few stray water-worn rocks.
5. A bed, like No. 3, with fragments of fossils, capped with loose layers of limestone 18 inches to 2 feet thick.
4. Three inches of light-yellow clay, a hard layer.
3. Yellow indurated calcareous clay, full of shells, *Chonetes granulifera*, *Spirifer plano-convexus*, &c., 10 inches.
2. Several layers of hard limestone, very compact, with crinoids, corals, *Chonetes granulifera*, *Athyris subtilita*, *Spirifer cameratus*, *Productus semi-reticulatus*, &c., 6 feet.
1. Greenish yellow clay, underneath the most valuable and massive bed of limestone, 20 inches thick. Below the clay, but only exposed by removing the earth, is a layer of yellow limestone 18 inches thick.

Bed 2 in the above section produces the best rock for building purposes, and the organic remains indicate its geological position to be in the Upper Coal-Measures.

I then visited the quarries along the north bank of the Platte with Messrs. Clark and Watson, of Bellevue. The first point examined was Duclos's quarry, about four miles above the mouth of the Platte. Here are some most excellent limestones for building purposes, and blocks of large size are taken out for the Omaha market. Upon the principal layer rests a bed of yellow clay, filled with water-worn pebbles of small size, usually 2 or 3 inches in diameter, 3 to 4 feet thick. Above this is yellow marl of indefinite thickness. The surface of the rock seems to have been planed smooth, probably by glacial action, as if by the hand of art, so that as far as exposed by the stripping off of the superincumbent clay and marl beds, no portion of the surface seems to be higher than another. The main scratches or grooves are 27° east of north; but there are some exceptions, 19°, 23°, 27° east of north. There is one groove crossing the main scratches nearly north and south. The observations were taken with great care with a large surveyor's compass, belonging to Mr. Watson. Mr. W. regarded the variation at this point as 11¾°. The entire process seems to have been rather a smoothing one, with a few small pebbles in the bottom of the glaciers. A section at this quarry, in descending order, reveals the following beds:

6. Yellow marl. Loess.
5. Yellow clay, full of white lumps of magnesia, with small pebbles.
4. A layer of limestone varying from 10 to 15 inches in thickness, which makes most excellent lime and building blocks. *Athyris subtilita*, *Fusulina cylindrica*, and *Spirifer cameratus*.
3. Slope, doubtless intercalations of clay and thin beds of rock, 30 feet.
2. Massive layers of limestone, yellowish-white, full of organic remains. *Spirifer cameratus*, *Athyris subtilita*. *Productus semi-reticulatus*, *Fusulina cylindrica*. The fusulina very abundant in the middle layers, 10 to 15 feet.
1. Slope, same as bed 3, 25 feet above the Platte.

About two miles above Duclos's quarry, the little streams cut deep valleys along the region of the Platte, exposing some beds which doubtless hold a lower position than those last mentioned. Some very fine springs issue from these rocks, which are regarded with great favor. In the vicinity of these springs there is usually a large accumulation of tufaceous deposits, sometimes forming large masses like thick layers of porous or spongy limestone. All along the Platte the beds are concealed except near the foot of the bluffs, and the following section is disclosed by artificial cuttings:

5. Greenish-yellow and brown clays with irregular hard layers of limestone, 2 to 6 inches thick, 10 to 15 feet.
4. Reddish clay, 2 feet.
3. Heavy, bedded, bluish limestone, very hard, 6 to 8 feet.
2. Yellowish laminated clay, 2 feet.
1. Bluish, hard, argillaceous limestone, 12 to 18 inches.

The Carlisle quarries are about ten miles above the mouth of the Platte. The rock here is a blue limestone in layers 2 to 12 inches thick, with intercalations of clay 1 or 2 inches thick. It breaks into fine blocks for caps and sills, and is much sought after. Near Fair View, just below the mouth of Buffalo Creek, a section was taken:

8. Yellowish calcareous clay, full of *Fusalina cylindrica*, 2 to 4 feet.
7. Yellowish indurated clay, 18 inches.
6. Rather porous, impure limestone, 12 inches.
5. Yellow and ash-colored clay, 2 feet.
4. Massive yellow limestone, very good, full of organic remains, *Allorisma*, *Athyris*, *Productus*, &c., 3 to 4 feet.
3. Slope.
2. Limestone.
1. Slope.

Farther up the Platte bed 4 appears again; and always, wherever it occurs, forms most valuable quarries for the inhabitants. All these layers of limestone continue nearly to the mouth of the Elkhorn, gradually passing by a gentle dip beneath the Cretaceous sandstone. Near the mouth of the Elkhorn and along that stream are several bluffs of the yellow sandstone, soft, and yielding readily to atmospheric influences; but the mural faces are often covered with hieroglyphics, so that they seem to have been of some service to the Indian on which to record his history.

In summing up the geology of these two counties we can at a glance see the simplicity of its character. A few beds of the Upper Coal-Measures and the rusty sandstones of the lowest division of the Cretaceous series, the Dakota Group, are all that occur. We find at one or two localities the Cretaceous and Carboniferous beds in apposition; and though the eye can observe no apparent want of conformity in these beds, yet we can readily imagine the tremendous effects of the erosion prior to the deposition of the sandstone, from the fact that hundreds of feet of clays and limestones must have been swept away.

The first interesting feature in the geology of this district is the vast deposit of yellow marl or Loess, which covers the whole of Eastern Nebraska. Although I shall allude to this deposit quite often in another portion of this report, yet it will be as well to define it as clearly as possible in this connection. Above the basis rocks there is generally a considerable thickness of a deposit which goes under the general name of Drift. Near Omaha it is 40 or 50 feet in thickness composed of loose sand, waterworn pebbles, &c., the layers of deposition inclining at all angles. Indeed,

there is every evidence of turbulent waters during its deposition. Mingled with the water-worn pebbles are fragments of iron ore, and often thin layers of rusty sand, which shows that a large portion of the materials of this drift is derived from the washing away of the Cretaceous rocks. The coarse gravel gradually passes up into fine sand, then clay, and not unfrequently the clay graduates up into the yellow marl. In most instances the bluffs of yellow marl present a massive front, without any signs of stratification. Sometimes there are indistinct traces of stratification, but, as a general rule, the yellow marl indicates a deposition in very quiet waters, probably in a lake. This yellow marl is sometimes called the bluff formation, from the fact that it forms the greater portion of the high hills bordering the Missouri River on either side. Indeed, it is this formation that gives the contour to the hills and character to the entire surface of the country forming Eastern Nebraska. But its most powerful influence upon this region lies in the wonderful fertility which it has imparted to all soils, lowland or upland. It varies from 5 to 150 feet in thickness in different places; yet, throughout its entire thickness, it is filled with nutritious matter for the growth of vegetation. It is owing to the universal distribution of this marl that the underlying basis rocks are so rarely revealed to the eye of the geologist. Passing westward from Omaha, as far as the eye can reach, nothing can be seen but one series after another of rounded hills or long sloping ridges. The yielding nature of this marl is such that it wears away into gentle slopes, so that traveling is not difficult; yet there is no more variation in the form of the surface than in that of the sea when agitated by the winds. This, too, is a great advantage to the country, for on this account the drainage is perfect. Sometimes the farmers complain that their farms are rough and not as desirable, but this feature will be regarded at some future period as most important in the cultivation of certain crops. This marl was called, many years ago, Loess by Mr. Lyell, who examined it along the banks of the Mississippi. It forms the characteristic features of the hills along the Missouri and the Mississippi from the Great Bend to the Gulf of Mexico. But through the State of Missouri, so far as I have observed it, it contains more clay. The hills upon which the village of St. Joseph is located are fine examples of the yellow marl. Here very deep artificial excavations have been made. Scattered through it everywhere is an abundance of land and fresh-water shells which all belong, so far as we know, to recent species; a great variety of the genus *Helix*, also *Limnea*, *Physa*, *Planorbis Pupa*, *Succinnea*, valves of *Cyclas*, and some others. These shells, of course, illustrate its purely fresh-water character. This marl is also often filled with whitish calcareous concretions or nodules, which are sometimes hollow. These nodules are especially abundant at the foot of the lofty marl bluffs which form the precipitous range of hills along the Missouri River below the mouth of the Big Sioux. Not unfrequently the bones of extinct animals, mingled with those existing at the present time, are found in this marl. The bones and skull of the buffalo often occur. A most excellent skull of the buffalo was recently found in the marl bluffs near Dakota City, 30 feet below the surface. Near Plattsmouth Rev. J. G. Miller obtained the bones and skull of a rodent, enveloped in one of these calcareous concretions, which on examination proved to belong to the *Geomys bursarius*, pouched or pocket gopher. This animal is still very abundant all over the rock bottoms of the Missouri from mouth to source, and yet we determine from this specimen that it extended back in time to the period of the Loess and was a cotemporary with the mas*todon and elephant.* In a large number of localities the bones and

teeth of mastodons and of the beaver have been found. The teeth of the *Mastodon giganteus* and *Elephas primigenius* are not uncommon. This carries us far back into the past, when the great valley of the Missouri, or a large portion of it, was one vast fresh-water lake, with its myriads of streams pouring in from every side, on the shores of which tramped the huge mastodon and elephant, along with the smaller quadrupeds that now inhabit this region. The beaver also built his dams along the streams, and cut the timber that grew along the banks, while the gopher burrowed, as now, under the rich soil of the bottoms. As I have before remarked, this yellow-marl formation has sometimes been called the Loess from a similar deposit which exists in the valley of the Rhine, and which has given this valley a celebrity in song and story all over the world. The vine-clad hills of the Rhine, and the delicious wine, have long been associated with this district; and if grape-vines that will withstand the severity of the climate can be found, these hills along the Missouri River will rival those along the Rhine in the abundance of the grapes and the income of their vineyards.

There is another feature in the scenery along the Missouri which should not be overlooked here, from the fact that it is quite conspicuous, and contains within itself a most important truth, throwing much light on the history of the great West. The terraces along the Missouri and many of its tributaries are not confined to the district where the yellow marl is deposited, for I have seen these terraces even more numerous and conspicuous about the sources of the Missouri and Yellowstone, and they are described as occurring in the valley of the Columbia and other rivers, flowing into the Pacific. They are doubtless instructive as showing the pauses that occurred in the upward rising of the country during the elevation of the Rocky Mountain range. There is generally the uncertain sandy bottom next to the river, then an abrupt terrace, 4 to 15 feet high, which forms the proper river bottom; then comes the second terrace, which also varies much in height above the river bed of from a few feet to 100 or 150 feet. The city of Omaha is located on one of these high terraces, which is almost entirely composed of yellow marl. This terrace slopes gently up to the foot of the marl hills, when the ascent becomes more abrupt.

It is not often that the terrace is worn away into the rounded hills, as shown near Council Bluffs. Sometimes there are three or four of these terraces, but usually not more than two conspicuous ones. When the terraces are well shown on one side of a river they seem to be wanting on the opposite side. Bellevue is also located on a high terrace overlooking a vast extent of country, and so fine is the location and so beautiful the prospect that it has called forth the involuntary admiration of travelers from Lewis and Clark to those of the present time. In a purely economic view this deposit is of very great value to the settlers. The erosion of the limestones and clays of the Upper Coal-Measures alone could never have given such wonderful fertility to the soil of Nebraska; indeed, it is almost or entirely independent of it. Indeed, it is composed of a mixture of the eroded materials of all the formations in the Missouri Valley, and particularly of the Cretaceous and Tertiary formations and the soft, yielding, chalky limestone of No. 3 Cretaceous enters largely into its composition. I made collections of the soils and the yellow marls from various localities. They are now in the possession of Professor S. W. Johnson, of Yale College, for analysis, and no report has yet been made. In the excellent report of Professor Swallow on the geology of Missouri, 1855, several analyses of yellow marl from different points are *given as conducted by* Professor Litton. Professor L.

also gives a table of analyses of the Loess of the Rhine, and I will quote it here to show how closely related these two deposits seem to be in their chemical composition. It is not to be supposed that they are necessarily synchronous in their deposition, as some of the older formations are supposed to be, but merely this, that similar causes have produced similar results. The Loess of the Rhine may have been deposited in a quiet lake, and the materials may have been composed of the eroded débris of the rocks of a similar chemical composition. It will be seen also that those chemical constituents predominate in the yellow marl that are useful for the growth of the different cereals. In one hundred parts of this marl, dried, from near Hannibal, Missouri, analyzed by Dr. Litton, there were, from two analyses—

	1.	2.
Silica	76.98	77.02
Alumina and peroxide of iron	11.54	12.10
Lime	3.87	3.25
Magnesia	1.68	1.63
Carbonic acid	Not determined.	2.83
Water	2.01	2.43
	96.17	99.26

Brick made from this formation, from the same locality, gave the following result:

Silica	79.52
Alumina and peroxide of iron	12.80
Lime	3.45
Magnesia	1.95
Carbonic acid and water	1.11
	98.83

Bischoff's analyses of the Loess of the Rhine.

Number of analysis.	1st.	2d.	3d.	4th.	5th.
Silicic acid	58.97	79.53	78.61	62.43	81.04
Alumina	9.97	13.45	15.26	7.51	9.75
Peroxide of iron	4.25	4.81		5.14	6.67
Lime	0.02	0.02	.....	.....	.....
Magnesia	0.04	0.06	0.91	0.21	0.27
Potash	0.11	1.05	3.31	1.75	2.27
Soda	0.84	1.14			
Carbonate of lime	20.16	.....	.....	11.63	.....
Carbonate of magnesia	4.21	.....	.....	3.02	.....
Loss by ignition	1.37	.....	1.89	2.31	.....

The table of five analyses is taken from Bischoff's Chemical Geology, and it will be seen at once that the two deposits are not essentially different from each other chemically. This deposit is found everywhere along the Missouri River to the Great Bend, and for a considerable distance up all the tributaries of that river. It gradually thins out as we proceed westward until it disappears beyond the mouth of Loup Fork. This shows clearly that the deposit was made after all the great watercourses in the West were marked out, and was one of the latest of the important geological events in this region.

CHAPTER II.

CASS, OTOE, AND NEMAHA COUNTIES.

Cass County.—This county lies immediately south of the Platte River, and borders on the Missouri. It is one of the most fertile and productive counties in the State. The Weeping Water, a considerable stream, passes nearly diagonally through it and flows into the Missouri near the little town of Wyoming. The Platte forms the north limit and the Missouri the east, so that it seems to be most favorably located so far as water is concerned. But while this proximity to streams renders a large portion of the surface very rolling, or rough, as the farmers term it, there is undoubtedly more wood-land on that account. Along the Missouri there is a good supply of timber, and a young growth of trees is continually aggressing upon the prairie portion. If not removed by the ax or destroyed by fire, these hills and valleys will, in a few years, be clothed with a thick growth of valuable timber. Among the ravines of the Platte are a great number of patches of oak, sufficient for fuel, on every farm. Then again, along the valley of the Weeping Water there is a good deal of excellent wood-land, and an abundance of limestone for all kinds of building purposes, and some excellent mill-sites. Nearly all the farms are occupied by actual settlers, and the crops of wheat, during the autumn of 1867, were unsurpassed by any other portion of the United States. I should judge also that this county is settled by a thrifty and intelligent class of farmers, for we find not only well-cultivated farms, with neat farm-houses, but also neat churches and school-houses. The entire county is covered with an immense thickness of the yellow marl which conceals all the basis rocks except along the streams.

As in the counties already described, only the Upper Coal-Measures and the Cretaceous rocks are found. Along the Platte, about twelve miles west of Plattsmouth, and from thence to the mouth of Salt Creek, there are numerous quarries of the rusty sandstones of the Dakota Group. In these sandstones are numerous impressions of dicotyledonous leaves similar to those found at Blackbird Hills, Decatur, and other localities to the northward. Near Plattsmouth is a series of beds of clays, sandstones, and limestones of the Carboniferous period, and corresponding with those already noticed on the north side of the Platte. Near the summit of the hill is a layer of limestone four to six feet in thickness, which has been much wrought for building materials. As the superincumbent clays and marls are stripped off, a smooth surface is revealed, with indistinct scratches, the same as seen on the opposite side of the Platte. How extensive this planing operation was carried on in this region it is impossible to tell, yet, according to the investigations of Dr. White in Iowa, this glacial action must have extended over a large area, and perhaps over all the Northwest. In a very interesting article by Dr. White, published in the American Journal of Science for May, 1867, entitled "Observations upon the Drift Phenomena in Southern Iowa," he states that as far back as 1858 he discovered distinct glacial scratches on an exposed layer of the upper Burlington limestone. During the past season he discovered other traces of this action on limestones of the Upper Coal-Measures in Mills County. In Nebraska these scratches have been observed at Omaha, on the Platte, and along the Missouri below the mouth of the Platte, and the inference is a just one that, if the great thickness of drift and yellow marl could be removed from the surface of the limestones, we should find that this glacial action was universal. This is undoubtedly the beginning of a

series of events which continued up into the present period. I hope to be able to discuss this matter more fully in another part of this report. Through the great kindness of the Rev. J. G. Miller, of Plattsmouth, I was able to examine much more of this county than I could otherwise have done, and by his aid I secured all the essential points. On our way to Weeping Water from Plattsmouth we pass over a rolling prairie country underlaid with yellow marl, but having a surface soil of almost unexampled fertility. Near Eight-Mile Grove, at Mr. Austin's, we could ascertain, approximately, the thickness of the yellow marl at that distance from the river. A well dug 30 feet revealed no rocky layer on high ground and away from the main water-courses. The water is excellent. Near Mr. A.'s house there is a peat-bed that will undoubtedly be of some value when wrought. The peat appears to be two or three feet thick. There are several of these peat marshes in this neighborhood. In the valley of Weeping Water there is a bed of light-yellow limestone—a few layers compact and good for building purposes. It is mostly brittle, breaking into irregular fragments, with no true regular cleavage. A fine large mill and several houses are constructed of this limestone in the valley. The fossils are quite rare. The grassy slopes are so numerous everywhere that I found it difficult to secure a full section of the rocks.

7. Limestone, hard, whitish, and yellowish-white; cropping out at the summits of the hills, and lying on the slopes in large masses 8 to 10 feet thick.
6. Slope, 20 to 30 feet.
5. Layers of bluish limestone, brittle and cherty; full of flint, 6 to 8 inches thick, and breaking into square blocks 6 to 8 feet thick.
4. Slope, 20 to 30 feet.
3. Shelving limestone, yellow, not very useful for buildings; underneath this is a small bed of clay which forms a slope.
2. Yellowish-white, brittle limestone, with much sulphuret of iron in cavities.
1. Shale or black slate.

These limestones are often filled with the comminuted fragments of fossils, as corals, bryozoa, and stems of crinoids, and not unfrequently thick layers are made up of an aggregate of the *Fusulina*, so that when the rock disintegrates the surface looks sometimes as if it was covered to a considerable thickness with grains of wheat. The crinoids are extremely abundant in their fragmentary condition, but it is very seldom that a specimen can be found sufficiently perfect to be characterized. Near the mouth of Stone Creek, section 12, range 10, township 10, indications of coal have been observed. Mr. E. L. Reed, residing at the little village of Weeping Water, sunk a shaft through the following beds:

9. Sandstones, which form the bed of the creek, 10 feet.
8. Slate and clay, 3 feet.
7. Coal, 9 inches.
6. Whitish, fire clay, 3 feet.
5. Crystalline quartz, 3 inches.
4. Bluish clay, 4 feet.
3. Whitish, fire clay, 6 feet.
2. Red clay, 3 feet.
1. Soft white limestone, —.

The coal above, although so thin a seam as to render it unprofitable for working, is of good quality, and is useful to the blacksmiths in the

vicinity. These alternate beds of limestones, sands, and clays give to the surface of the country bordering on the Weeping Water an unusually rugged character. The bottoms of the little streams are narrow, the soil is good, water excellent, and the valley is well settled and is prosperous.

Near the residence of Dr. Childs, about fourteen miles west of Plattsmouth, is a bed of red earth under the Cretaceous sandstones which looks like red ocher. There is along the Platte, in this county, connected with the Cretaceous sandstones, quite a series of the variegated sands and clays of the Dakota Group, which must, at some future time, be made very useful for economical purposes. Still at this time there is so much excellent limestone in this county that the wants of the settlers are fully supplied. There are many beautiful houses built of limestone. This rock seems to work easily into any desirable shape. I have estimated that the quarries of this county would supply the whole State with building material for many years to come; and where I examined the clays and sands they are quite inexhaustible. The demand for fuel will never be as good in this county as in some of the others farther west, on account of the supply of wood-land; but I would ask the attention of the farmers to the importance of peat as an article of fuel at some future time, or as an article of trade with the counties west. I am confident that a moderate supply at least can be found in this county, and that it will soon become an earnest object of pursuit and a source of great profit. But, like all the eastern portion of Nebraska, the great wealth of this county lies in its inexhaustible soil, which yields the most abundant crops. The wheat crops will average 30 to 35 bushels per acre; oats, 40 to 50; and corn, 60 to 75, while for grazing and stock-raising the whole country is unsurpassed by any portion of the globe. With all these facts before us, it is very easy to predict for eastern Nebraska a remarkable destiny in the future.

Otoe and Nemaha Counties.—The geology of all the counties bordering on the Missouri south of the Platte has been so ably and minutely discussed by Mr. Meek, in his report, that I shall allude to it only in a general way, although the geological structure of this district seems very simple. Yet, to trace out the details of the beds, so as to be satisfied with the perfect accuracy of the work, is very difficult. The Carboniferous rocks of Nebraska are made up of a series of layers of limestones, sandstones, sands, and clays of all colors and composition, and, unlike the rocky beds of nearly all the older Paleozoic periods, there seems to be no persistency in the lithology over even small areas. No two sections of strata not eighteen miles apart are alike, and the same bed changes apparently in short distances. If a very careful section of the beds, as revealed in some natural exposure along the Missouri River, is taken, it will fail to correspond with the results of a boring farther into the interior. Sections of the natural exposures at Plattsmouth, Nebraska City, Brownsville, Rulo, or White Cloud, on the Missouri, will fail to correspond, except in some few particulars, and the vast thickness of yellow marl, which conceals the underlying rocks over such a great extent, leaves considerable intervals continually, over which it is impossible to trace out the beds. These Upper Coal-Measure rocks seem to be as changeable in their lithological characters as those of the Tertiary period. What adds to the difficulty, also, is the fact that the same species of fossils, with few exceptions, run through all the beds. Many of the same species run through all the beds that are exposed by the Missouri, from Leavenworth City to Omaha. As has been shown by Mr. Meek, *both these counties are underlaid* by rocks of the Upper Coal-

Measures, or Permo-Carboniferous. The Cretaceous sandstones have not been observed on the western borders, and it is probable that the Cretaceous belt extends westward beyond the limits. If the western portions of these two counties could be stripped of this thick covering of marl, it is very probable that true Permo-Carboniferous beds, and, quite possibly, true Permian would be disclosed at some points. The efforts in search of coal in Nebraska have so far been unsuccessful, but so important does it seem to be to the inhabitants that a source of mineral fuel should be found somewhere within the limits of the State, that its existence or non-existence becomes the most important problem for solution connected with the survey. In succeeding portions of this report, I shall allude frequently to outcroppings and seams of coal in various portions of the State; but, inasmuch as so great interest has been taken in this question by gentlemen at Nebraska City, it will not be out of place to discuss the matter briefly now. Mr. Meek, in his report, has discussed the probabilities of the existence of a bed of coal within accessible distance of the surface within the limits of the State with his usual care, and he has given the details of the sections shown by the borings at different localities. His opinion seems to be unfavorable to success anywhere within the limits of the State. As far back as 1862, I published a paragraph in a memoir read before the American Philosophical Society in Philadelphia, referring to some indications of coal along the banks of the Platte, which had attracted the attention of settlers:

A seam of carbonaceous shale, 12 to 18 inches in thickness, crops out occasionally near the water's edge, and is regarded by the inhabitants as a sure indication of coal. The great scarcity of timber throughout this region would render such a discovery of the highest importance, but I am inclined to the opinion that it is a geological impossibility for a workable seam of coal to be found within the limits of the Territory of Nebraska. The limestones of southeastern Nebraska belong to the Upper Coal-Measures, and form the extreme northwestern rim of the great coal-basin, and, inasmuch as the strata dip toward the northwest, in ascending the river, at least one foot to the mile, there must be from 600 to 1,000 feet of clays, shales, and limestones over the first seam of coal two feet in thickness, in any part of the country near the mouth of the Platte. A bed of coal, to be really valuable for economical purposes, should be at least three feet in thickness, and even then it would not prove profitable if a large amount of labor were required in opening the mine.

It had always been my opinion that the Coal-Measure rocks of Nebraska were located on the western rim of the great coal basin of the West, and that a profitable bed of coal would never be found within a workable distance of the surface. During the survey many facts bearing on that point were secured which we had never known previously. The fact that the Union Pacific Railroad Company had bored 400 feet at Omaha; that Mr. Croxton had bored down nearly the same distance at Nebraska City, without passing through any important seam of coal, seemed discouraging. Now, if we go still lower down the river, where the rocks hold a position several hundred feet lower in the geological scale than at Nebraska City, at Atchison, St. Joseph, Leavenworth, and some other localities, we shall find that borings have been made 400 or 500 feet with no better success. Again, if we examine a small but valuable memoir on the geology of Northern Missouri, by Mr. Broadhead, we shall find that in this paper he gives a continuous section of the beds as they are seen in their natural exposures, of 2,000 feet or more in thickness, including the Upper Coal-Measures and a part or all the Middle Coal-Measures, and yet he does not find a seam of coal over 2 or 2½ feet in thickness. Another fact seems to me to possess considerable weight. In the valley of the Des Moines, in the Lower Coal-Measures, are found several beds of coal varying in thickness from 1 to 7 feet. The fact

that these seams of coal were not more than one hundred or one hundred and thirty miles east of Nebraska City gave encouragement that the same seams would be penetrated at the latter place at a reasonable depth. But it is probable that in the western extension there is a thinning out of the beds of coal and shale and a thickening of the limestones, clays, and sands. It is now well known that the Carboniferous limestones disclosed by the elevation of the Rocky Mountains are of the same age as those along the Missouri in Nebraska, Iowa, and Kansas. We believe that these beds pass beneath the more recent deposits in Nebraska only to reappear again along the margins of the mountains, and we have no reason to suppose that the continuity of Carboniferous rocks from the Missouri River to the mountains is interrupted underneath the Tertiary, Cretaceous, or other deposits. Now all along the margins of the mountains, from the north line to the Arkansas, there are no black shales or indications of coal in the Carboniferous rocks that would deceive the most hopeful. The beds are for the most part massive limestones, or fine, compact sandstones, and the entire absence of irregular beds of sands, clays, seams of shale or coal, would seem to indicate that the Carboniferous rocks passed through these changes gradually in their extension westward. These facts point to the conclusion, as I have before mentioned, that Nebraska lies on the western border of the coal-basin, and however deep borings may be carried anywhere along the Missouri River no seams of coal over 2 or 2½ feet will ever be penetrated. As a matter of course it is not possible to decide this point positively except by actual boring, and it certainly would be a good plan to extend a boring down a distance of 1,000 or 1,200 feet to settle the question for all time to come. This disposition of the question in Nebraska settles it for a vast area along the Missouri River of the finest land in the west.

A large portion of Kansas, Northern Missouri, Iowa, Nebraska, and Dakota Territory will be found destitute of mineral fuel. Mr. J. Sterling Morton sunk a shaft on his farm near Nebraska City, and bored down about 100 feet more, but with no indications of coal. There is a seam of coal near the river at this place, which has been wrought by drifting in a distance of 300 yards, and the seam was about 8 inches in thickness, and several thousands of bushels of coal have been taken from it. At Otoe City, eight miles below Nebraska City, there is a bed of slate and coal about 8 inches thick, which has been worked to some extent, and the coal used in blacksmith shops. Again, at Brownsville there is a seam of coal accompanied by some of the plants peculiar to the Coal-Measures. There is from 4 to 6 inches of coal, and the whole bed, coal and slate, is about 12 inches in thickness. There is also a fine quarry of limestone at this point, which is of a very superior quality for building purposes, but it contains too much sand and clay to make a good article of lime. There is also a bed of fine-grained, micaceous sandstone, which cleaves naturally into excellent flagstones. Indeed, the rock quarries in this county are of great value to the inhabitants. The materials for making brick abound everywhere in this region; clays, sands, and marls are abundant and of excellent quality. At Aspinwall, in Nemaha County, we discovered the most favorable exhibition of coal yet observed in the State. The general dip of the beds seems to be up the Missouri, or nearly north or northwest. It is difficult to determine this point with precision. The rocks at Aspinwall are all geologically at a little lower horizon than the Nebraska City beds, and mostly beneath the Brownsville beds. Two seams of coal are met with at

Aspinwall; one crops out near the river, about 15 feet above the water, 24 inches in thickness—very good quality. A few feet above this seam is a second seam—six inches of good coal. Some English miners are sinking a shaft here, with full confidence that the thickest bed can be made profitable, and I am inclined to think that, with the present scarcity of fuel, they will succeed well. Coal commands a ready sale at from 40 cents to 80 cents per bushel; and even at 80 cents a bushel coal is cheaper than wood. The miners have already sunk the shaft about 40 feet, have passed through the 6-inch seam, and are confident of soon reaching the 24-inch bed, when the work of drifting in various directions will commence and the coal be taken out for market. The beds hold such a position here that, if these miners are successful, this effort determines the existence of a workable bed of coal for Nemaha, Richardson, Pawnee, and Johnson Counties, which will be a most important matter for the whole State. We have very abundant notes in detail, and many specimens to illustrate the geology of the river counties. I am informed that excellent hydraulic lime for cement exists in Nemaha County, section 9, township 6, range 14, but I have not been able yet to make a personal examination of the locality. In both counties there are many indications of extensive peat-beds, which must attract the attention due them before many years. Mr. McPherson, of Brownsville, informed me that just twelve miles west of that town he had observed an extensive area, which appeared to be a peat-bog, into which he thrust a pole to the depth of 10 or 12 feet. It is not to be supposed that in this dry climate any very extensive peat-bogs, like those in New England or other portions of the Atlantic coast, but a bog with peat 2 feet in depth even, would be of great value. The counties of Otoe, Nemaha, and Richardson contain more timber than any others in the State.

CHAPTER III.

RICHARDSON AND PAWNEE COUNTIES.

The two counties above named are in some respects the finest in the State. Forming as they do the southeastern boundary of the State they are located geographically in that portion in which the extreme cold does not have so powerful an influence. All the fruits and cereals peculiar to northern temperate zones can be raised here in perfection. Peaches, pears, apples and grapes do well; while north of the Platte it is doubtful even yet whether the cultivation of fruits is an entire success. In the northern parts of the State several kinds of fruits must fail on account of the severity of the climate during the winter months.

There is more woodland in Richardson County than in any other portion of the State, and on this account very little attention has been paid to the planting of trees. While there are many excellent farmers here and there, and the county is quite thickly settled, there is not that thrift that is found in Nemaha and Pawnee Counties. The greater part of the land, however, has been taken up by actual settlers, who are now devoting themselves to the improvement of their farms, and to the raising of large crops. There is a ready market for all kinds of produce at the highest price. Although nearly all the settlers came into the county poor, many without any money at all, nearly all are becoming moderately rich, and every man with industry and prudence may become independent in a few years. This country may certainly be called the

poor man's paradise. There is scarcely a foot of land in the whole county that is not susceptible of cultivation. I have never known a region where there is so little waste land. The underlying rocks of the whole county belong to the age of the Upper Coal-measures, and are composed of alternate beds of limestones, sandstones, and clays of almost all colors, textures and compositions. There are several localities along the Missouri River and the larger streams where there are good natural exposures of the rocks, but as a rule the beds are concealed by the superficial covering of yellow marl or Loess, which gives the beautiful, undulating outline to the surface, the gentle slopes, with only now and then an exposure of the basis rocks. This aids in rendering the investigation of the geological structure of the county more complicated and difficult. The river counties present better exposures of the rocks than any other counties in the State, and it is partly on this account that I have given them my first attention. Even these exposures are by no means good.

In my last communication I spoke of the coal-seam at Aspinwall, Nemaha County; that about 16 feet above the water level of the Missouri a bed of coal 22 to 24 inches in thickness was observed cropping out from the bluff; and a few feet above this, in the same range of hills, was a second seam, 6 inches in thickness. These beds do not appear again for considerable distance down the river, until we come to Rulo, except at one or two localities near St. Stephens. At Arago I saw no outcroppings of coal at all, and could not hear that any had been observed; but there are some good quarries of limestone, beds of clay, sands, &c. The next marked exhibition of coal is at Rulo and its neighborhood, about two miles above Rulo, on land belonging to Mr. S. F. Nuckolls, of Nebraska City. At this locality Mr. N. has drifted into the bank 100 feet or more, and taken thence over 200 bushels of coal, which has been used by blacksmiths with success. The outcrop was about 5 inches in thickness, but increased as the drift was extended in the bank, to 11 inches, and again suddenly diminished to 1 inch of good coal, the remainder being composed of impurities, or niddy coal, as the miner called it. The coal which has been thus far taken from this mine sells readily for 35 to 40 cents per bushel. The abrupt termination of the coal-seam, or "fault," is undoubtedly due to the sliding down toward the river of the superincumbent beds—a phenomenon which is very common everywhere along the Missouri. Still the irregularity in the thickness of this coal-seam is everywhere apparent, vibrating between 4 and 20 inches, thus alternately exalting and depressing the hopes and prospects of the miner. On the farm belonging to Mr. St. Louis, about one and one-fourth miles below Rulo, the same bed of coal has been worked with some success by drifting, and a considerable quantity of coal taken out. Mr. St. Louis unwisely sunk a shaft at a higher point on the hill, thinking to cut the coal-seam at a more favorable spot, the expense attending it, exhausting his means at 45 feet. He sunk a drill, however, into the bed of coal and found it 12 feet below the position at the outcrop, showing an extensive inclination of the beds from the river, or toward the west.

This dip may be readily accounted for by the extensive erosion of the rock prior to the deposition of the yellow marl and drift deposits, which erosion has given rise to many perplexing local inclinations of strata. These local dips will not interfere with the miner so much, farther in the interior of the county. The thickness of the coal-bed at this locality is 10 to 12 inches, increasing in one instance to 17 inches. On the Iowa reserve, along the Great Nemaha River, the same bed again crops out in the ravines or banks of little streams, and has been wrought with

some success, several hundred bushels of the coal having been taken out from time to time for several years past. The country along the Nemaha is quite rugged, or "rough," as it is termed by the settlers, owing to the several beds of sandstone, and the overlying or cap rock of the coal-bed, which prevents the water from forming gentle slopes, as in the case of the more yielding clays or marl-beds. This bed of coal is probably the equivalent of the 2-foot bed seen at Aspinwall, while the upper 6-inch bed is not exposed at all. The rocks in contact with the coal are as follows:

Underlying the coal, a bed of light-gray fire-clay, full of fragments of plants, as fern-leaves, *Neuropterisc Loschei*, and *N. hirsuta*, stems of rushes, calamites, &c., the same as occur in the underlying clays in Ohio and Illinois coal-fields. Above the coal there is about four feet of very hard laminated or shaly clay, varying from black to dark-ash color, all of which must be removed with great labor before the bed of limestone, or cap rock, as it is called, can afford suitable protection to the miner as he drifts into the bank. Thus the small amount of coal is obtained with great labor, and it is only the great scarcity of fuel that will warrant any labor being expended upon it at all.

We passed over the almost treeless prairie, from Rulo to Falls City, the county seat, about nine miles distant. Some beds of limestone crop out from the hills occasionally, but usually all the basis rocks are concealed from view, and the surface is gently and beautifully undulating. The fertility of the soil is everywhere shown by the luxuriance of the crops. Falls City is located upon high ground overlooking the valley of the Nemaha. There is not a native shrub or tree of any size growing within a mile of the town. Although the same coal-bearing beds formed the underlying basis rocks about Falls City, yet not an outcropping of coal could be found in the vicinity. Some good quarries, however, were examined. Having heard that a boring had been made at Hiawatha, the county seat of Brown County, Kansas, ten miles south of Falls City, I visited that place to ascertain the result. I was informed that a company had bored near that place 240 feet without success, and that the project had been abandoned; and as the strata in all this region are very nearly horizontal, the same result would follow any attempt at boring at Falls City, to that depth at least. About nine miles southeast of Hiawatha a bed of coal is worked with considerable success, and many hundred bushels of coal are taken out of the mines and sold annually. Mr. Laycock, a lawyer at Hiawatha, informed me that during the past winter he used about 130 bushels of coal, for which he paid 50 cents per bushel; and he found it cheaper than wood, even at that price. He spoke highly of its qualities as fuel. I am disposed to believe that it is the same bed seen along the Missouri, in Nemaha and Richardson Counties, although I did not examine it in person. Continuing our course westward to Salem, we observed no marked change in the country; indeed, there is a remarkable uniformity in the character of the country over a large area. The changes that take place are usually the result of some change in the underlying geological formations, and are, therefore, quite gradual. No outcroppings of coal could be found at Salem or vicinity, and it is quite possible that none will be found exposed to the surface in that portion of the county, except along the Missouri River. I am convinced, however, that boring at a moderate depth at almost any point would penetrate the thin bed seen at Rulo. The quarries of limestone for building purposes, &c., are much finer at Salem than at any other point observed in the county. The town is located upon an elevation on the point of the wedge of

land between the two forks of the Nemaha. Forming a part of the town site is a high hill, with two beds of limestone, both of which form large quarries, which yield an abundance of stone for all economical purposes. All along the Nemaha and its numerous branches are quite well-wooded tracts of land, which are held at a high price, though no portion of the country would be called well timbered in any of the States east of the Mississippi.

Although there is less wood-land in Pawnee County, it is equally fertile with Richardson, and the latter possesses only the geographical advantage of bordering on the great navigable river Missouri. Its surface is more rolling or undulating, the slopes are more gentle, and to the eye it seems even more desirable for farming purposes. Both counties are remarkably well drained by nature; so there is scarcely a foot of land in either that is not susceptible of cultivation. I cannot ascertain that one county produces better crops than the other. Pawnee County is remarkably well watered. The numerous branches of the North and South Nemaha, circulating all over it, render the land very attractive to the settler and speculator, who have already absorbed every acre of it. Both counties are underlaid by rocks of the Upper Coal-measures, which give a very great uniformity of character to their surface. The rocks are composed of alternate beds of clays, sandstones, and limestones, with some thin beds of coal. At Salem the succession of the beds is about as follows:

10. Yellowish-gray soft limestone, 3 feet.
9. Slope.
8. Very compact white limestone, brittle, about 12 inches thick, caps the hills.
7. Slope, 50 feet.
6. A very porous, yellow limestone, 2 feet.
5. A layer of laminated, impure, rather rotten limestone, dirty yellow, with *Spirifer planoconvexus*, *S. Kentuckensis*, *Pleurophorus occidentalis*, *Hemipronetes crassus*, *Productus semireticulatus*.
4. Dark, laminated, arenaceous clay, mostly fine sand, 5 feet.
3. A very irregular bed of laminated fine sandstone; sometimes the bed is 2 feet, gradually increasing to 4 feet.
2. Dark, ash-colored, indurated clay, unusually hard, 5 feet.
1. Bluish, very hard clay, becoming yellow on exposure, 2 feet above water.

Up one of the little branches of the Nemaha, in Salem, I found about 4 feet thickness of black shale, or slate, which was not exposed at the mill. The cap rock, above the shale, is full of fossils. In the shale the *Lingula*, probably *L. Scotica* and *Orbiculoidea*, occur in considerable quantities. On Contrary Creek there is a small exposure of the basis rocks of this region:

4. Yellowish laminated shale, with a thin layer of deep-yellow, fine clay, 4 feet.
3. Blue indurated clay, 3 feet.
2. Rather hard layer of limestone, 6 inches; *Chonetes granulifera*, *Productus Prattenanus*, *P. Nebrascensis*, *Spirifer planoconvexus*.
1. Yellow indurated clay.

On Isaac Trigg's farm, seven miles west of Salem, I obtained some fossils from a well. The surface was about 20 feet above the Nemaha, and dry. Twenty-five feet before reaching water, near the bottom of the well, is a bed of shale, in which were species of *Myalina* and *Aviculopecten*.

At Miles's ranche, about 20 feet above the bed of the Nemaha, is a

dark-bluish layer of fine, argillaceous limestone, which cleaves easily but makes good stone for buildings, about 10 inches thick. Above is a layer of yellow shale; then limestone, very brittle, with *Productus*, *Myalina subquadrata*, &c. The succession of the beds is thus shown:

8. Bluish, close-grained, argillaceous limestone.
7. Slope.
6. Gray arenaceous limestone, fine-grained fragments of organic remains or shells, and fish teeth, 4 feet.
5. Dark, ash-colored, laminated, indurated clay, somewhat variable in character, 30 feet.
4. Impure fibrous gypsum, and fine, light-gray, indurated, slaty clay, 4 inches.
3. Bluish indurated clay shale, 11 inches.
2. Light, ash-colored clay slate, 12 inches.
1. Bluish-black indurated clay, 6 feet above water.

Bed 6 of the above section would yield most excellent building-stone, and may be quarried out in immense blocks. All these beds seem to change their character over short areas. This bed has much the appearance of one seen at Plattsmouth, though the evidence is not positive. The hills, for 200 feet in height in this region, have little layers of limestone cropping out. The whole country along the Nemaha is much broken—more than usual—yet the fertility of the soil is very great. On Mr. Wheeler's farm, section 31, township 2, range 14, the basis rocks crop out again: 1st, shale; 2d, yellow clay, 2 feet; 3d, impure limestone, intercalated with clay, 3 feet; 4th, blue clay, 6 feet. In the third layer occur shales with *Aviculopecten*, *Productus*, *Spirifer planoconvexus*, &c. The valley of the Nemaha seems nowhere in this region to be destitute of good building-stone. As we proceed westward, even as far as Salem, the yellow marl, which is so conspicuous a feature along the Missouri, begins to grow thinner, so that in digging wells the basis rock is soon reached. This marl is somewhat unequally distributed over the country, but where it is found it renders the soil very productive. The bottom lands of the Nemaha are quite broad here, covered with a luxuriant growth of grass yielding two or three tons of hay to the acre. Water is reached in wells, at a depth of 15 to 25 feet, without passing through the alluvial soil. On Four-mile Creek, ten miles southwest of Salem, a bed of rock crops out, which is the same as the upper bed at Salem, and might be called fusulina limestone. It caps the hills on section 12, township 1, range 13. Other fossils occur, as *Aviculopecten*, *Spirifer planoconvexus*, *Pleurophorus occidentalis*, &c.

On Turner's Branch, a small stream flowing into the Nemaha, there is a seam of coal that has been worked with much labor. The principal drifts are on school section, township 1, range 12, one and a-half mile northeast of Freize's mills:

4. Massive yellow limestone; upper part cleaving.
3. Dark, ash-colored laminated clay, with two or three black bands, 2 to 4 inches thick. The whole mass is filled with shells—*Productus Nebrascensis*, *P. longispinus*, *Chonetes granulifera*, *Spirifer planoconvexus*, *Retzia punctulifera*, *Spriferina Kentuckensis*, *Hemipronites crassus*, *Bryozoa*, &c.
2. Coal, 4 to 16 inches thick, very variable in thickness and quality.
1. Yellow plastic clay, passing up into a hard blue clay, upon which the coal lies as if pressed down, 20 feet thick.

No rocks below bed 1 are seen in this immediate vicinity. The coal seemed to be packed closely down on to the clay beneath, like masses of

flat rock, as if it had been originally deposited there like a layer of clay or sand. The clay below is quite hard and filled with fragments of fern leaves, stems of the rush-like calamites, like the clay underneath the coal seams in Ohio or Pennsylvania. The under surface of the coal seems to be composed of stems, like grasses, as if the vegetable débris began upon a densely grass-covered surface. The vegetable impressions do not go down into the clay more than an inch or two, and above the seam, where the coal ceases, all traces of vegetable matter disappear, and the clay is charged with a variety of molluscous remains. The clay above the coal is very hard, and yields with difficulty to the pick, and the coal is extracted with great labor. Several hundred bushels have been taken out and sold, and the bank of the creek reveals fifteen or twenty openings like that shown by the illustration. This shows the coal seam at the base, the bed of indurated clay above, which is generally 3 to 4 feet thick, all of which has to be removed, and the heavy-bedded limestone forms an excellent cap-rock above. At Frieze's Mill, still further on, this same bed of coal is again wrought with some success.

On Mr. Boston's farm, township 1, range 12, section 34, several openings have been made; and here the coal seam increases in thickness to 16 inches. Mr. B. has taken out 900 bushels of coal here. He finds a ready market for it at the mine at 30 cents per bushel. This coal seam averages a bushel of coal to a square foot of surface. I have collected abundant specimens of this coal at different localities, and they will be properly investigated at some future time.

This seam is also worked on Lee's Branch and on Miner's Creek, so that it is now wrought, more or less, over an area of ten miles square, at least. The coal seems to have been worked with more system, industry, and success than in any other portion of the State.

Near Pawnee City there is another small seam of coal holding a higher geological position, which has attracted some attention. I made a careful examination of all the localities, and found it not more than 4 inches in thickness generally. On Mr. Jordan's farm, at the water-level of Turkey Creek, a branch of South Nemaha, this seam increased to 8 inches, but is so impure and full of sulphuret of iron as to be quite unfit for use. Near Pawnee City, on a little branch of Turkey Creek, about 300 yards south of the city line, the beds succeed each other as follows:

5. Yellow, fine-grained sandstone, 20 feet.
4. A close-grained, bluish, ash-colored argillaceous limestone.
3. Two to four inches of coal, with large masses of sulphuret of iron.
2. Plastic fire-clay, nearly white, passing down into yellow clay and sand, 12 inches.
1. Yellow, arenaceous laminated clay, mostly sand, and quite firm in some parts.

At numerous localities in this county sections like those that are given above might be written, but as they teach nothing more than this, that the rocks all belong to the Upper Coal-measures, and that they are very variable in their character, it is not worth while to report them. We learn, also, that the seams of coal, so far as they have been opened, are very thin, and, although we suppose that the seam on Turner's Branch and at Frieze's Mill is the same as the one exposed at Pawnee City, the long intervals over which the rocks are concealed by superficial marl renders it impossible to trace all these beds out in their continuity, but as the inclination of the strata seems to be west or northwest, higher and higher beds must be constantly making their appearance. Throughout this county the uniformity in the specific character

of the fossils running through all the beds is another obstacle. If certain species were restricted to certain beds we could then trace them with more certainty; but our hasty examination always reveals from any one bed, or series of beds, certain fossils identical in species; and if at any one locality any species seem to be wanting that occur at another, a closer examination generally reveals them all. It is somewhat doubtful whether in the whole of Pawnee County a single species of shell was found that is not also found along the bluffs of the Missouri. In this county, however, several beds of limestone make their appearance on the high lands which have not been seen east, showing the direction of the dip. On a piece of land belonging to Governor Butler there is the best quarry of limestone I have seen in the county. The bed crops out near the edge of a hill bordering a small stream about eight miles west of Pawnee City. It is soft, cream-colored rock, full of small cavities, by the decaying out of a small shell. *Fusulina cylindrica*, *Spirifer cametus* also occurs. It is a true fusulina limestone, and is a great favorite with masons for building purposes. It is easily wrought into any desirable shape, is very tenacious in texture, and durable. It seems to hold a position about 100 feet above the water level of Turkey Creek, and belongs to the age of the "Permo-Carboniferous," or intermediate between the Upper Coal-measures and the Permian series, the general inclination of the beds being toward the west and northwest. New and more recent beds are continually making their appearance as we proceed toward the west, and this choice bed of limestone has made its appearance here for the first time. It will doubtless be found to extend over considerable area in a southeasterly direction. There is still another bed of bluish limestone cropping out of the hills, which, though useful, is not regarded with the favor bestowed on that just mentioned. It does not dress as nicely, is not as handsome for caps or sills. It is equally durable with the other. There are several beds in the county which are employed, to a greater or less extent, for various economical purposes.

About three miles north of Pawnee City, about 50 feet above a little branch of the North Nemaha, is a ledge of yellowish-gray limestone cropping out of the hills, filled with a very large variety of the *Fusulina*. It is much used for building purposes. At another locality in the same region, at about the same level, is another quarry in which the rocky layers seem to be made up of an aggregate of small masses, apparently organic and like *Fusulina*. The bed is 4 to 6 feet in thickness, and although the rock has a loose, porous texture, it is very tenacious, and is very useful to the settlers. This bed, though holding nearly the same geological position as that mentioned above as occurring on Governor Butler's farm, is, I think, underneath, and both belong to the series designated in this report as *Permo-Carboniferous*. As we proceed farther west of this point we shall find the beds more and more recent and approaching gradually the character and texture of the true Permian rocks, as shown near Junction City, in Kansas. Peat-beds occur in various portions of the county, sufficient, I think, to attract attention at some future time. Near Pawnee City there is a small peat-bog, on which one may stand and jar the ground for considerable distance around. I estimated the peat here at 10 or 12 feet in thickness. These low wet places are covered with water a large portion of the year, and give rise to a luxuriant growth of the large rushes and reed grasses of the country. This vegetable dies down every year; from its decay grows a still more luxuriant growth, which furnishes an abode for the muskrat, which builds its conical houses. Water is abundant all over the county. Scarcely a section of land can be found in the two eastern tiers of counties without a running

stream or a flowing spring. Water is obtained everywhere, by digging, at moderate depths. Near the little streams it is only necessary to go down a little below the river bed and the best of water flows in abundantly, and on the high land water is usually found at a moderate depth. Nearly all the wells have a continual supply from 6 to 10 feet. In the limestone region the water is usually hard on account of the carbonate of lime, but it is cool and clear as crystal and very pleasant to the taste. I cannot well conceive of a healthier region either for man or beast. As a grazing country Nebraska presents unusual facilities, and the time must come when it will be unsurpassed by any State in the Union. Having described most of the counties underlaid by the Upper Carboniferous rocks, I might say a few words here in regard to the possible outline of the surface of them prior to the deposition of the yellow marl. We see, all along the Missouri River, that this comparatively recent deposit attained there a great thickness, varying at different localities from 50 to 150 feet. As we go westward from the river this deposit gradually grows thinner until it finally disappears. The question now arises as to the influence it had on the character of the scenery of this region. Even if this yellow marl did not exist here, there must have been some superficial deposit of drift or alluvial to conceal, in part at least, the underlying or basis rocks, and the character of the surface would depend somewhat on the thickness and compactness of this superficial material. We could safely infer, from the evidence we have obtained, that prior to the deposition of the yellow marl the outline of the surface underlaid with the Upper Coal-measure rocks was exceedingly rugged. Sometimes the foundation of a house dug on a high hill will rest upon the true limestones; again, a well dug will pass through the clays, sands, or limestones of the basis formations. Then, in other localities, wells are dug from 30 to 100 feet through the yellow marl without ever reaching the bottom of the alluvial or drift material; but it is especially along the bottoms of streams that the superficial deposits appear to be so deep. If we can imagine the superficial materials entirely removed from the county, the surface, as it seems to me, would be rugged in the extreme. The valleys of the streams would be much deeper and wider, and the massive piles of limestones would stand around here and there, scattered over the surface like gigantic ruins. Evidences of glacial action also would be visible, as well as striking examples of erosive action—numerous valleys with almost perpendicular rocky sides, high conical hills capped with ledges of limestones; indeed, so rugged would be the surface that it would be quite uninhabitable. The distribution over it of the thick deposit of soft-yielding marl has softened down all the slopes, so that not only is nearly every foot of land susceptible of cultivation, but the drainage is complete. To these causes are due the almost unparalleled agricultural resources. The source of all this material may be somewhat difficult to determine, but in another portion of this report I will bring together all the information that I can secure in relation to it.

CHAPTER IV.

GAGE AND JEFFERSON COUNTIES.

Gage County.—After having examined Pawnee County with considerable care, with the kind aid of many excellent friends, we took a course nearly southeast across the open, high prairie, passing over the divide

between the valley of the Nemaha and that of the Big Blue. Very few exposures of rock were to be seen, the surface is rolling, covered with a luxuriant growth of grass that would yield two or three tons to the acre. Here I saw the first long stretch of treeless, waterless prairie, reminding one somewhat of the prairies farther west. There was no living water, and not a house along the road for several miles. The soil, however, is extremely rich, a thick deposit of yellow marl covering the whole surface. The compass plant, *Silphium laciniatum*, is still seen in great abundance on highland and lowland, attesting by its presence the fertility of the soil. About seven miles northeast of the Otoe reservation we see the first outcrop of limestone from the hills, forming a sort of terrace about 50 feet above the beds of the streams. The gentle slopes and the entire absence of outcrops of rock over so long a distance from Pawnee City, are doubtless due to beds of soft yielding clay and sand prevailing, which readily yield to atmospheric agencies; while the beds of limestone, yielding less readily, form a sort of cap or floor protecting the softer beds below. This border rock always gives to the surface a more abruptly rugged character, the little branches have steeper banks, and there is greater variety to the scenery. At the Otoe agency this same bed of limestone is again exposed. It is quite cherty, breaking into small fragments. There are one or two layers, 6 to 12 inches in thickness, that would furnish good materials for building purposes. The following section was obtained at several localities within two miles of the agency buildings, and gives a fair view of the succession of the beds on the Indian reservation:

7. Superficial deposits of soil and yellow marl.
6. Yellowish-white limestone, rather soft, yielding readily to atmospheric influences, 2 feet.
5. Slope same as No. 3, below.
4. Yellow, fine-grained, arenaceous limestone, 18 inches.
3. Slope supposed to be laminated clay, but covered with grass, 20 feet.
2. Yellow and gray limestone filled with seams and nodules of schist or flint. A large species of *Orbiculoidea* occurs here.
1. Bluish-gray, laminated, calcareous clay, with numerous fragments of fossils, crinoids, corals—*Productus semi-reticulatus*, *Meekella striatocostata*, &c., 30 feet above water's edge.

The Otoe reserve is located on the Big Blue River, mostly in the southern portion of Gage County, but extending into Jefferson County. It occupies a surface 10 by 24 square miles = 153,600 acres of the finest land in Southern Nebraska. The Big Blue, one of the most beautiful of the inland streams, with several of its most important branches, passes through it. Like all other portions of the State, there is comparatively little timber, yet as much as on other streams. Some of the branches have the most desirable farms bordering on them. The Otoe Indians occupy a small village bordering on the Blue and are not distributed over the reserve. The land is not divided out to them, but they are all aggregated together in a village of mud huts. They seem to have no idea of individual independence, but have all things in common, as it were. The bed of cherty limestone extends beyond Blue Spring and forms the same bluff-like bench along all the streams; it then passes beneath the water level of the Blue. Near Blue Spring this bed presents much the appearance of mason-work, the cherty material forming the cement between the blocks of limestone. These bluffs are about 10 or 15 feet high, and as they are cut through by the myriads of little streams pouring down from the hills, they present a rather rugged

appearance. A few fossils were obtained here, as *Athyris subtilita*, *Hemipronetes crassus*, *Syntrilasma hemiplicata*, with bryozoa and crinoidal remains. Near the ford at Blue Spring there is an excellent mill site, and the settlers here have quarried the rock down to the water's edge, for the purpose of building a dam and laying the foundations of a mill. The succession of the beds here is as follows. All of them are below the cherty bed spoken of:

3. About 10 inches soil, 8 feet yellow marl, 2 feet worn pebbles and sand. Roots of trees pass all through this bed into the joints of the limestone.
2. Layers of cherty nodules, variable in thickness, with intercalations of fine gray sand, 2 to 2½ feet, *Productus semireticulatus*, *Hemipronetes crassus*.
1. Bluish, ash-colored argillaceous limestone, easily decomposing in water, but hardening on exposure.

This bed is made up of layers varying from a few inches to two feet in thickness, separated by thin layers of clay. It makes quite good building-stone—*Productus*, *Pinna peracuta*, *Orbiculoidea*, *Myalina subquadrata*. Underneath the argillaceous limestone there is a bed, about a foot above water's edge, of ash-colored clay, breaking into small angular fragments, containing in it irregular seams of agillaceous limestone. Beds similar to these are seen on the Nemaha, but it is impossible to say that they are identical. It is probable that they are not, but simply a portion of the series coming to view continually as we proceed eastward. On the west side of the Blue River the slopes are all very gentle, the ascent being very gradual as far back as the eye can reach. There is no sign of the cherty bed which causes the bluffs and terrace on the east side. The bottoms are everywhere very rich and black, but the hills are covered with a heavy deposit of yellow marl, so deep yellow that I suspect it to be composed mostly of the eroded materials of the Cretaceous and White River Tertiary formations. On the bottom of the Blue Mr. Tylor dug a well 25 feet deep, reaching water near the level of the bottom of the river. At the Blue Spring Village a well was dug on high ground 55 feet deep, through clays and quicksands, without reaching the basis rocks. At a depth of 54 feet a large bone was found, which probably belonged to the mastodon. The water came in in great quantities, and is of the finest quality. On John Hagen's farm a well was dug 44½ feet through alluvial marl and gravel. The water rushed in with great power, and is now 8 feet deep. The wells show the depth of the superficial deposits, and we are enabled to ascertain to some extent their influence on the county. We know that in the valley of the Big Blue the soil is inexhaustible, and that the water is of the best quality, and abundant everywhere. About five miles west of Blue Spring, on the road to Beatrice, there are layers of yellow limestone, that are used for building purposes. Two miles farther there is a bed of yellow magnesia limestone, with *Aviculopecten*, *Syntrilasma hemiplicata*. The rock is 15 to 20 feet thick, arranged in layers 6 inches to 2 feet in thickness, and is full of geode-like cavities, with the same white crystalline lining "calc-spar" inside as seen at Blue Spring. Beatrice, the county seat of Gage County, is very pleasantly located on the Big Blue, with many natural advantages for becoming a prosperous town. The inhabitants are energetic and thriving; the land is fertile, and an abundance of excellent building material exists everywhere; the water is pure and abundant, and the climate is very healthy. On a little

branch of the Big Blue there is an exposure of the rocks favorable for a section.

6. Dark-brown ferruginous sandstones of variable color and texture; used for buildings; contains many deciduous leaves; 50 to 60 feet.
5. Yellowish-gray sandstone; soft, easily crumbling, and wearing away exposed; on Blakely's Run, two miles west of Beatrice; 30 to 50 feet.
4. Slope in most places, but composed of variegated clays of doubtful age; potter's clay; 40 to 50 feet.
3. Loose layers of yellow limestone, full of geode cavities; porous, spongy. *Syntrilasma hemiplicata*, *Pinna peracuta*.
2. Yellow, rather compact limestone; good for building purposes; 2 to 2½ feet.
1. Dark-gray argillaceous limestone, becoming light gray on exposure, filled with geodes, with cavities full of crystals of carbonate of lime. This bed is at times massive, heavy-bedded limestone, of a beautiful cream-color; 10 feet.

Beds 1, 2, and 3 of the above section are undoubtedly of Permian or Permo-Carboniferous age, though they contain fossils common to both Permian and Carboniferous rocks.

Bed 4 is of doubtful age. Beds 5 and 6 are exceedingly interesting in a geological point of view, from the fact that they represent a new geological formation not before seen east of this point.

Bed 4 seems to form a sort of transition bed between the Permian* and Carboniferous formations. The Permian rocks pass beneath the water level at Beatrice, westward, and over a belt ten to fifteen miles wide, in a northeast and southwest direction, the brown sandstones prevail to the exclusion of all other rocks.

I should think that the Cretaceous sandstone in this region was 30 to 50 feet thick, though from the sliding down of the rocks it was impossible to tell with accuracy. The sandstone is very variable; sometimes coarse, friable, dark-rust color; sometimes in flat masses, with the appearance of pot metal; then a laminated sandstone. Underneath the rusty sandstone is a friable bed which will afford an abundance of good coarse sand. When unmixed with the drift gravel this sand is pure and beautiful. In the sandstone are many impressions of dicotyledonous leaves. I did not see the sandstone at all on the east side of the Platte, but on the west side it crops out of the high, thin-soiled hills. In the deep ravines the abrupt cliffs of limestone are seen. Between the rusty sandstone and the limestone there is a considerable thickness of fine sands and clays, which everywhere wear down in gentle grassy slopes, concealing the junction of the two formations. Therefore I was not able to find them in apposition.

The west side of the Big Blue is a little hilly, but the east side, between Indian Creek and the Blue, is very level and gently rolling, as if the underlying rock was of a soft material, and had been worn down over a large surface nearly alike. Gage County, so far as I have seen it, begins to reveal some of the indications that show we are on the borders of the dry western belt. The long intervals without living water, the peculiar flowering plants, and some of the prairie grasses, and the absence of trees, even the small shrubs, show that we are verging on the dry prairie. The *Schrankea uncinata*, sensitive plant, is seen here for the first time.

The soil of Gage County does not equal that of Pawnee County, or

* It is not certain that the true Permian beds, as recognized in Kansas, extend northward into Nebraska, though thin beds may occur in some of the southern counties.

the counties along the Missouri, as a whole. The bottom-lands are excellent, but the upland soil is thin. The grass is less luxuriant, and the timber along the streams less abundant. For wheat, however, this soil, composed as it is largely of the eroded materials of the Cretaceous sandstones, contains a large amount of silica, and seems to be most favorable. A bushel weighs more than that of the river counties, but the corn and other kinds of grain are not quite so good. Yet too much cannot be said in favor of Gage County as an agricultural and grazing region. No coal will ever be found there, and the sooner the farmers commence planting trees the more prosperous they will be. Comparatively little peat will be found in the county, so that the question of fuel must be determined by the intelligence and industry of the people. If they plant trees now, they cannot suffer for fuel, for before that which they now have is gone, the planted forests will be ready for use. In regard to fruits, garden vegetables, &c., the same may be said of Gage County as of the other counties before described. Success will attend all well-directed efforts that way. The excellence of the water in springs and wells in this county is a most important feature, in a sanitary point of view.

There are no minerals that can be worked to advantage in this portion of the State. In the Cretaceous rocks there are large masses of limonite, (hydrated sesquioxide of iron,) but they are so full of siliceous matter that they can never be of much value. Even if there was an abundance of iron in this county there is no fuel to prepare it for use.

Jefferson County.—From Beatrice to Rock Creek, a distance of twenty-two miles, we passed over an open prairie without wood or water. Indeed, as we go westward there are whole townships of land without a tree or a particle of running water. The grass is good, and though the soil is thin on the high hills, the lower slopes and bottoms are as fertile as ever. Wheat, oats, corn, and all the cereals grow well. Water can be obtained at moderate depths, for the drainage is not good. There are miles of level surface without a ravine or channel to receive the water, and therefore it must quietly sink through the superficial beds to some reservoir of clay. It is plain that a little above Beatrice, on the Big Blue, No. 1 Cretaceous comes down to the water level by a rapid dip, and that the Permian and Carboniferous beds cease to appear in their westward extension.

On Rock Creek, a small branch of the Little Blue River, we find the rusty sandstones of the Dakota Group largely developed, and the readiness with which they yield to the erosive action of water has given to all the ravines of the Little Blue a very rugged appearance. The rocks also are so porous that the water readily permeates them, so that there is comparatively little in the ravines a large portion of the year. Still, in the valley of the Little Blue there are some as fine springs as are to be found in the State, but they are somewhat rare. A section in descending order along the Little Blue, below the Big Sandy, would be as follows:

5. Yellow and dark-brown rust-colored sandstones of the Cretaceous or Dakota Group, so well known in many other portions of the West. A few dicotyledonous leaves were found. This bed is of irregular thickness; from 50 to 100 feet.
4. Moderately-coarse, yellowish-white sand, with irregular laminæ of deposition; 50 feet.
3. Dark-colored, arenaceous, laminated clays, with particles and seams of carbonaceous matter. All through are beds of carbonaceous clay,

18 inches to 3 feet thick; much sulphuret of iron and silicified wood; 30 to 50 feet.

2. Variegated arenaceous clays; the slopes exposed are so great that I cannot give the exact thickness; probably 50 to 70 feet; some seams of excellent potter's clay.
1. Dark bluish shaly clay, upon which the foundation of Mr. Jenkins's mill rests. It is undoubtedly Permian or Permo-Carboniferous, but is not exposed to view by natural excavations until we reach a point south of the Nebraska line near Marysville, Kansas.

Beds 1 and 2 of the above section are seen at Mr. Jenkins's mill. Bed 2 is also shown, two miles above, along the bottom hills of the Little Blue. The variegated clays come under the white, incoherent sandstone. The dark band in bed No. 3 has been regarded by the settlers with a good deal of interest, as indicating the proximity of a workable bed of coal. I gave all the exposures a careful examination and found them of no possible value. At Jenkins's Mill there is a very fine spring of pure water flowing out just under the sandstone. The water, as it percolates readily through the porous sandstone, reveals the hard clay bed and remains upon this almost impermeable surface. I am convinced that the black hard shales upon which the mill rests belong to the Permian, and that the variegated sands and clays are intermediate between the sandstone and the true Permian. The excavations are going on now below the bed of the river, and Mr. Jenkins informs me that the shale becomes harder as he proceeds downward. The Kansas line is only about one and one-half miles below this mill, and about two miles below on the Blue, the yellow limestones appear. Not more than fifty or sixty miles south of this point, at Junction City, Kansas, the Permian rocks are well shown, and we would reasonably expect they would extend northward into Nebraska in the valley of the Little Blue. On Rock Creek there is not water enough in wells a portion of the year for culinary purposes, and wells have been dug in that neighborhood sixty feet in depth without reaching any water. In the intermediate variegated sand and clay beds, which I regard as belonging to the Dakota Group, just below the mill, is a locality where there is a band of laminated clay and sand, with seams of coaly matter, petrified wood, sulphuret of iron, selenite, &c. The whole bed looks much like an ash-heap. There are many fragments of wood, much of it as light as dry wood; others seem to be simply charred. This bed is also full of bits of arenaceous rock, thin layers of rust-colored, fine-grained argillaceous concretions, full of oxide of iron, all of which give to the bed a singularly sterile or barren appearance. On the west side of the Little Blue, on the high hills, there is an extensive quarry of the gray sandstone in the form of broad, flat masses, which will work into good building-stone. In the absence of better stone, this becomes very useful to the settlers. On Rose Creek, just above its entrance into the Little Blue, the variegated bed, wood and pyrites bed, and the incoherent sand bed, all come together. On Coal Creek, a little branch of Rose Creek, there is a perpendicular bluff showing the following succession of beds:

4. Fine loose sand, varying in color from white to a dark rusty red. In this bed are some thin layers of harder rock, 30 feet.
3. Black carbonaceous clay filled with bits of charcoal, clay, &c., 18 inches, and passing up into 2 to 4 inches of yellow clay mixed with bits of coal.
2. White fine clay, 2 feet.
1. Variegated clay, 20 feet.

Bed 4 is very irregular in its composition; sometimes there are 3 or 4 feet in thickness of very fine, whitish, slightly-arenaceous clay, with waved laminæ and sesquioxide of iron; then again the sand-bed is almost pure white sand. Just above bed 3, in the section, there is a thin layer, one-fourth to one inch thick, which has the appearance of having been baked from below, caused by the ignition of the lignite beneath. On the way up to the Big Sandy, for twelve miles or more, these clays and sands are seen occasionally with the red rocks. On the summits of the hills, but above the mouth of Rock Creek, the hills are not rugged, and the sandstone does not form any bold cliffs. About two miles below the mouth of the Big Sandy, No. 3 is seen on the summits of the hills, not in ledges, but in outcrops of loose slabs of limestone. These slabs or large flat masses are really only an aggregate of the shells of *Inoceramus problematicus*. South of this point there is no limestone to be found in the State along the valley of the Little Blue, and, therefore, it becomes a matter of some importance; it is much used for lime by the settlers. As we proceed up the valley of the Little Blue, the bottoms become more sandy and gravelly, and the vegetation of both lowland and highland exhibits a marked change. The basis of the alluvial material is the eroded materials of No. 1. In the hills are some naked patches of flesh-colored marl, and over the surface are scattered very thickly, water-worn pebbles and some quite large quartzite granitic boulders. The entire features of the country exhibit a distinct approach to the arid belt. That we are verging upon it there is not a doubt. Yet a finer country for stock cannot be found in the world. Horses, cattle, and sheep would thrive on the short nutritious grasses. The numerous broken masses of rock and the drift pebbles among the hills would be favorable for the sheep. For good farms a suitable quantity of good level land can be found, but the successful farmer must combine stock-raising with agriculture. Wheat grows here in great perfection, while oats, corn, and all kinds of garden vegetables do well. At the entrance of the Big Sandy there is a very wide bottom, at least three miles long and one mile wide, with soil from 6 to 10 inches deep. The Big Sandy is almost twelve yards wide where it enters the Little Blue, and is a stream of fine clear water. As we go westward from this point the limestones of No. 3 take possession of the country. On the high hills the limestones of No. 3 crop out in great abundance, and they everywhere seem to be mostly made up of *Inoceramus*. Lower is a bed of laminated shale which seems to pass gradually down into Cretaceous No. 2, though the line of demarcation between No. 3 and No. 2 cannot be seen. It is only the upper portion that so strongly resembles No. 3, as seen on the Upper Missouri. Below it is a gray shale, with some sand between the thin sheets of clay or limestone, but the *Inoceramus problematicus*, which everywhere testifies to the presence of No. 3, is seen either entire or in fragments on the bluffs around. At one locality about three miles above the mouth of Big Sandy, on the Little Blue, section 20, township 3, range 1, west, there is an exposure of the shale 40 to 50 feet high, showing the slaty character perfectly, with slabs containing the *Inoceramus*. There are also seams of gypsum, colored with the oxide of iron, and crystals of the carbonate of lime. The saw-mill near this point rests upon a conglomerate which precisely resembles portions of No. 2, as shown along the Missouri, and in these conglomerate masses here, there are traces of *Inoceramus* and fragments of wood in great abundance.

One important feature in the valley of the Little Blue, are the terraces, which are quite marked *north of the Ne*braska line. There is really but

one, though sometimes there is a low one just above the immediate bed of the river, but the principal terrace is 25 to 50 feet above the water level. From that terrace the ascent is gradual to the summit of the high lands.

Leaving the valley of the Little Blue we took a course nearly northeast over the divide between Big Sandy and Swan Creek, a distance of about twenty miles, most of the way without water or wood. The soil is fertile and the surface is covered with a thick growth of grass. The valley of Swan Creek, a branch of Turkey Creek, which is a branch of the Big Blue, is a beautiful fertile one, with a large number of most productive farms. This region is settled with a large number of thrifty Germans, who are cultivating the land very successfully. But very little stone of any kind is seen in place in this valley. Yet the limestones of No. 3 furnish the materials for the foundations of buildings. The eroded materials of the limestones of No. 3 mixing with the sands of No. 1 make a most excellent soil. There is no rough land in this region; the bottoms are broad and the ascents on either side are very gradual, so that the hills bordering on the creek seem quite inconspicuous. The bottoms of Swan Creek will average three miles in length. All the basis rocks on the high lands are concealed from view by a large deposit of alluvial, which is composed of eroded materials from the basis rocks, with some water-worn pebbles; but strewed over the surface in many places are moderately-large blocks of quartzite, evidently deposited there at a comparatively modern period. Many of the hills are paved with pebbles as if they had formed the bottoms of small streams. The junction of Swan and Turkey Creeks with the Little Blue, being near each other, makes a broad valley which is now a fine farming region. Near this point there are the remains of an old Indian village. Fragments of pottery have been dug up three feet beneath the surface. I notice everywhere in the ploughed land that small pebbles are mixed with the soil, which is not the case in the two tiers of counties next to the Missouri River.

As I shall hereafter have occasion to refer often to the divisions of the Cretaceous group throughout this report, they will be better understood if defined more clearly in this connection. The Cretaceous rocks, as developed along the Missouri River, exhibit five quite well-marked divisions, which are characterized by peculiar fossils for the most part.

In a paper published in the proceedings of the Academy of Natural Sciences of Philadelphia, December, 1860, was given a general section of the Cretaceous rocks of the Northwest; long prior to that time Professor Hall and Mr. Meek had published the divisions by the numbers 1, 2, 3, 4, 5, but afterward Mr. Meek and the writer gave to them special geographical names. The sandstones which we have referred to in this report we denominated the Dakota Group or Formation No. 1, because these rocks were then supposed to reach their largest development along the Missouri River, near Dakota Territory. Formation No. 2 was called the Fort Benton Group, from the fact that it occurred in greatest thickness around Fort Benton, near the sources of the Missouri River. Formation No. 3 was named the Niobrara Division, from the conspicuous thickness of the bed near the mouth of the Niobrara River. These divisions constitute the lower series of Cretaceous rocks in the West, and are supposed to be the equivalent of the lower or gray chalk and upper greensand, by geologists. Formation No. 4 we called the Fort Pierre Group, because it reaches its greatest thickness near this point along the Missouri River. Formation No. 5 was called the Fox Hills Beds, from the fact that they form a conspicuous range of hills between the Big Cheyenne and Missouri Rivers. These two groups

constitute the Upper Cretaceous series, and though they are quite distinct in their lithological characters, a large number of the species are common to both groups, so that the line of separation can only be determined by the mineral nature of the beds. What I have said above is sufficient to render all references to these divisions clear to the reader, and they will be discussed more in detail in another part of this report. We find that as we proceed westward from Pawnee County, and in portions of that county, more and more recent formations come to view. We find that in Jefferson County Formations 1, 2, and 3 are revealed, and if we were to continue our course still farther westward we should probably find the geological structure the same as along the Platte, the White River Tertiary beds overlapping and concealing the chalky limestones of No. 3. So far as I have been able to make examination, Nos. 4 and 5 are not seen, though we cannot doubt of their existence somewhere underneath the Tertiary beds. They are all well shown on the Missouri River and along the eastern base of the mountains far south to the Arkansas, but along the Platte and all the little branches No. 3 is seen to a greater or less extent, with no trace of Nos. 4 and 5. These two groups may have been removed by erosion along the margins of the great Tertiary lake, prior to the deposition of the Tertiary beds, or they may be concealed from view by the great superficial marl or drift which forms the edges of the true Tertiary deposits. There is evidence to believe that the county next west of Jefferson is covered with the Tertiary beds, and that they continue westward to the western limit of the State. We know that at Fort Kearney the Tertiary beds are shown along the Platte, in their full development, with high, bluff hills, 200 to 300 feet in height. The hostile Indians were roving all over the county bordering on the Republican Fork, committing all manner of depredations, effectively preventing me from making an exploration of this interesting region, but it is safe to state that the colors on the map are very nearly or quite correct. As to the resources of that portion of the State covered with the Tertiary beds, it is safe to say it must be the same as that bordering on the Platte west of Fort Kearney. It will never make very good farming land, yet it may be inhabited sparsely by a pastoral people, for the surface is thickly covered with short, nutritious grasses.

CHAPTER V.

JOHNSON AND LANCASTER COUNTIES.

Johnson County.—The north branch of the Great Nemaha River runs nearly diagonally through Johnson County, in a southeasterly direction. It is the only important water-course in the county, and its value to the inhabitants cannot be overestimated. The entire county is underlaid by rocks of the age of the upper coal-measures; hence the geology is comparatively simple.

There are very few exposures along the Nemaha and its branches, and the high divides on either side present only rolling prairies covered with a luxuriant growth of grass, exhibiting every evidence of remarkable fertility, but having no timber and comparatively little living water.

From Beatrice our course was nearly northeast, passing over the divide between the waters of the Big Blue and those of the Nemaha. This divide, as usual, was treeless and nearly waterless for eighteen miles; yet, either to the right or to the left of our road, water and small trees

could have been found within five or six miles. The grass was excellent, showing a fertile soil, and the surface was monotonously beautiful to the eye, but not an exposure of the underlying rocks could be seen.

On Yankee Creek, a branch of the Nemaha, the first exhibition of the rocks was observed. A few limestone quarries were opened for obtaining building materials. The beds are thin, not more than from 6 to 12 inches in thickness, intercalated with beds of clay and sand. The surface is rather rugged, some abrupt hills, but usually clothed with grass down to the water's edge.

At Tecumseh a thin seam of coal has been opened, and is now worked with some success by Mr. Beatty. The drift is very similar to that before described in my report of Pawnee County, and extends into the bank about 100 yards. Mr. Beatty has taken out about 1,000 bushels of coal, which he sells readily at the mine for 25 cents per bushel. It is undoubtedly the same bed that is opened on Turner's Branch and at Frieze's Mill, in Pawnee County, but it is not quite as thick or as good; it contains large masses of the sulphuret of iron and other impurities The coal seam here varies much in thickness, from 10 to 15 inches. The cap-rock is a bed of limestone not more than 2 or 3 feet in thickness. A well was sunk in the village of Tecumseh 60 feet; a drill was driven down through rock and hard clay a few feet farther, and passed through what the workmen thought to be three feet of good coal. This discovery created much excitement at the time, and increased the demand for the public lands in Johnson County. It afterward turned out to be the same seam of coal worked by Mr. Beatty on the Nemaha, and was only 11 inches in thickness. The prospects, therefore, for workable beds of coal in Johnson County are no better than in the neighboring counties already examined. The succession of the beds at Beatty's coal-drift is nearly as follows:

9. Alluvial with pebbles. Small fragments of limestone. In this bed the tooth of a mastodon *(M. giganteus)* was found.
8. Hard layer of rusty limestone with seams of carbonate of lime all through, 4 to 6 inches.
7. Coal, varying in thickness and quality, 10 to 15 inches; contains much sulphuret of iron.
6. Blue potter's clay, 4 to 6 inches; rusty or light-gray sandstone, 20 inches, which is regarded as useful for whetstones.
5. Micaceous laminated grit, 16 feet.
4. Argillaceous limestone, full of fossils, *Myalina subquadrata*, *Hemipronites crassus.*
3. Reddish clay, 6 inches.
2. Reddish siliceous limestone, 15 inches.
1. Micaceous sandy grit, 20 inches.

In a bed of limestone, holding a high position in the hills, the following fossils were found: *Spirifer cameratus*, *Athyris subtilita*, *Syntrilasma hemiplicata*, *Productus semireticulatus.* These rocks prevail all over the county, so that the geology is very simple, the Upper Coal-measures only being revealed.

Tecumseh is the county seat of Johnson County, a small town located on the elevated prairie near Nemaha River.

From Tecumseh to the source of the Nemaha, about forty-five miles, I did not discover a single exposure of rock, and I could not ascertain that any had ever been observed by the settlers. We must conclude, therefore, that building materials in the shape of rock are not well dis-

tributed over the country; indeed, I do not know of any one in which I observed less.

From the sources of the Nemaha we passed over to those of Salt Creek. This county is very beautiful and productive. As a compensation for the absence of rocky layers the slopes are gentle and the creeks and ravines are grassed to the water's edge. I was told that a few building-stone were obtained on one of the little branches of the Nemaha. On Salt Creek, most outcroppings were seen down to the forks. The best quarries of limestone are on the farm of Mr. S. B. Mills. The west fork has very little stone on it except for about a mile above the junction. It is hardly necessary to give the succession of the beds. There are alternations of clay and limestone, and the limestones appear to belong to the transition or Permo-Carboniferous series. The fossils occur somewhat rarely, as *Productus semireticulatus*, *P. prattenianus*, *P. punctatus*, *P. costatus*, *Retzia punctulifera*, *Fusulina cylindrica*, *Fenestella Shumardi*. These limestones are exposed over an area of not more than five miles square. Their entire thickness cannot be more than from 15 to 20 feet, arranged in layers from six inches to two feet thick.

In abstracting the rocks from the quarry the fracture is so regular, breaking into massive square or oblong blocks, and the texture so fine, compact, and of light cream-color, that they are highly esteemed by builders, and make beautiful as well as durable houses. There are quite a number of large dwelling-houses made of this stone in the vicinity. It works quite easily. The finest springs of water in this country issue from this rock.

There are five or six of these quarries opened at this time, but the principal one occurs on the farm of Mr. S. B. Mills.

These fine quarries must become of great value to this country, for they yield the only good building material for thirty to fifty miles north, south, and west, and from ten to twenty miles east of the place.

The rusty, rather soft, friable sandstones of the Dakota Group are used, to some extent, for dwelling-houses. It presents an exceedingly somber and unpleasant appearance to the eye, and possesses no elements of durability. It can be relied on only in the absence of other building material. About twelve miles below these quarries, near the salt basins, Lincoln, the capital of the State, is located. Pretty good water is obtained here by digging, but there is a liability even then to strike brackish water, on account of the proximity to the salt lands.

From a point five miles above Lincoln to a point five miles above the mouth of Salt Creek, there is a scant supply of building material, of timber, and of fresh water; so that it can be seen at a glance that this valley is not as desirable as many other portions of the State.

Near Miss Warner's, about ten miles above Lincoln, a well was dug on the high hills, bordering the valley, to the depth of 60 feet, without striking rock. At Yankee Hill, two miles above Lincoln, a well was dug 66 feet, without reaching the basis rocks. These facts show the great thickness of the superficial alluvial deposits of this region, and also the skeleton form of the surface prior to the deposition of these deposits. I shall treat more fully on this subject at a future time.

The sandstones of the Dakota Group are quite largely developed in this region, and exhibit their usual variability of texture and color. The prevailing color is a deep drab rusty-brown, sometimes yellow, or nearly white. Some layers contain many impressions of dicotyledonous leaves. I was unable to find as large and perfect impressions as I have collected at many other localities.

So far as the surface of the country is concerned, in Lancaster County it may be regarded as remarkable for its beauty. It is always gently rolling, well drained, and from elevations the views are very fine, forming most excellent building sites. When the soil is not influenced by salt springs, it is equal to any in the State, but in an agricultural point of view there is no doubt that Salt Creek, with the numerous salt springs that issue forth near it, is a disadvantage to the valley. That portion about two miles above Lancaster does not seem affected by the salt. The farm of Mr. S. B. Mills, of over 1,000 acres, about ten miles above the county seat, is one of the most fertile and valuable in the State. Although the salt springs in this county may eventually be of some value to the State in the production of salt, yet I am convinced that if there was not a salt spring of any kind in the county, the difference in the value of the lands for agricultural and grazing purposes would much more than balance all income that will ever arise from the salt springs. In that case Salt Creek, instead of being almost useless, or rather an impediment, would be a fine fresh-water stream, making it one of the finest stock counties in the State.

The surface of the uplands lies very beautifully, is very attractive to the eye, but there is scarcely any timber in the county. The soil is excellent, and forest trees may be planted with success whenever settlers choose to do so, though very little has been done as yet.

The fact that the capital of the State is located in this county gives to it additional importance, and it also becomes a matter of no small interest to determine the true value of the salt springs that occur in this vicinity. The basins and scattering springs occupy a large area several miles in extent, but the main basin is located near the town of Lancaster. These basins are depressions in the surface nearly destitute of vegetation, and the white incrustations of salt give the surface the appearance in the distance of a sheet of water. The Great Basin, as it is called, is situated about one mile from Lancaster, township 10, range 6, section 22, and covers an area of about 400 acres. The brine issues from a large number of places all over the surface, but in small quantities. All the salt water that comes to the surface from this basin unites in one stream, and we estimated the entire amount of water that flowed from this basin at from six to eight gallons per minute. The second salt basin lies between Oak and Salt Creeks, and covers an area of 200 acres. Third basin is on Little Salt Creek, called Kenosha Basin, and covers 200 acres. Numerous small basins occur on Middle Creek, which occupy in all about 600 acres. Between Middle and Salt Creeks are several small basins, covering 40 or 50 acres. From the surface of all these basins more or less springs ooze out. In former years great quantities of salt have been taken from the surface and carried away. During the war as many as sixty families at a time have been located about these basins, employed in securing the salt.

Besides the numerous basins above mentioned, Salt Creek, Hayes's Branch, Middle Creek, Oak and Little Salt Creeks, have each a dozen springs coming out near the water's edge. One spring on Salt Creek issues from a sand rock, and gushes forth with a stream as large as a man's arm, at the rate of four gallons a minute. This is the largest spring known in the State. The geological formations in the vicinity are of the Upper Carboniferous and Lower Cretaceous age. The salt springs undoubtedly come up from a great depth, probably from the Upper Carboniferous rocks, and are the same in their history and character as those in Kansas. Two methods have been used to some extent in this region *in preparing the salt*—boiling and solar evaporation. The only method

which can be employed profitably in this country, where fuel is so scarce, is solar evaporation, and this can be carried on more effectually than in any State east of Nebraska. The unusual dryness of the atmosphere, the comparatively few moist or cloudy days, the fine wind which is ever blowing, will render evaporation easy. The surface indications do not lead me to believe that Nebraska will ever be a noted salt region. It seems to me that if all the brine that issues from all the basins and isolated springs were united in one they would not furnish more than brine enough to keep one good company employed.

What the result of boring will be can be determined only by actual experiment. Some large springs may yet be found in that way, but I saw no brine that was much stronger than ocean water. The rains have been so frequent this spring that it is much diluted with rain-water. The Nebraska Salt Company made, from July to November, 1866, 60,000 pounds of salt. Another company, at work at the same time, made about the same amount. Good working days 6,000 pounds have been made in a day. The kettles used for boiling are very rude steam boilers split into two parts. In a vat 12 by 24 feet average evaporation was 125 to 130 pounds per day. An extra day was 250 pounds. I think it not improbable that a company with a large capital, and employing all the improved methods of manufacturing the salt, would succeed. The salt is said to be good, though not as strong as the common salt of commerce.

Passing down Salt Creek toward its mouth, we see on every side a gentle undulating region covered with a fine growth of grass, with all the indications of a soil fertile and productive. There is but little timber in the valley of Salt Creek and its vicinity; very little in Lancaster County; and this deficiency should be remedied at once by the planting of trees. There is no good reason why every quarter-section in the country should not have a proper amount of wood-land in a few years. There are no indications of the Carboniferous limestones until we reach a point near Dean's Mill, and then the river on the east side exposes a considerable thickness of them, with numerous fossils. On the west side of Salt Creek the limestones do not appear, and this point may be considered the western limit on the south side of the Platte. About a mile above Ashland there is a quarry of the rusty sandstone, which is much used for building purposes. Houses are not built of them generally, but walls or fortifications are sometimes made of them. These red sandstone quarries are quite abundant along the road from Ashland to Plattsmouth, but they thin out on the summits of the hills about ten miles before reaching the latter place.

We do not see the Cretaceous sandstones in actual contact with the Carboniferous limestones, even along Salt Creek or along the Platte on the south side, but this is due, undoubtedly, to the beds of fine sand and clay that intervene, forming slopes. About fifteen miles east of Ashland a bed of fine, white, indurated sandy clay, with red streaks all through it, upon which the red sandstone rest. This bed is 20 or 30 feet in thickness, and can be made very useful for economical purposes.

At Ashland, near Dean's Mill, there is a pretty good thickness of limestone with irregular cleavage, 20 to 30 feet in thickness, extending down to the water's edge, and forming a rock bottom or ford. Above this is a slope of clay, probably, and then 18 inches of hard, yellow limestone, which is also quarried out. From thence to the summit of the hills the slope is 150 to 200 feet, covered with a heavy deposit of yellow marl; and if the basis rocks crop out at all, they are red sandstone. From the lower bed *at Dean's Mill I collected* a large number of fossils,

Productus semireticulatus, P. prattenianus, P. punctatus, P. costatus, P. wabashensis, Athyris subtilita, Meekella striato-costata, Syntrilasma hemiplicata, Retzia punctulifera, Spirifer lineatus, S. planoconvexus, S. kentuckensis, Hemipronites crassus, Chonetes granulifera, Fusulina cylindrica, Allorisma, Pinna peracuta, Schizodus wheeleri, Myalina subquadrata, Scaphihocinis, hemisphæricus, Fenestella, Lophophyllum, &c.

The above list of fossils will show at once that the limestones here, even up to the apposition of the Cretaceous beds, are Upper Coal-measure, and that the transition and Permian, if they were ever deposited here, have been swept away.

About five miles east of Ashland the succession of the beds is thus shown:

7. Sandstone, cropping out from the summits of the hills of Cretaceous age.
6. Slope, probably fine sand and clay.
5. Yellowish magnesian limestone, gradually passing down into harder broken layers, 10 to 20 feet thick, in layers 6 inches to 4 feet. The upper part is mostly made up of comminuted organic remains. I detected *Meekella striato-costata, Athyris subtilita, Fusulina cylindrica.*
4. Slope, 20 feet.
3. Layers of whitish limestone, very hard and good for lime, and for building purposes, 4 to 6 feet; *Fusulina, Athyris, Archeocidaris, Meekella,* crinoid stems and corals.
2. Slope 150 feet above the Platte; about 100 feet thick at this point.
1. A heavy ledge of rather brittle limestone full of *Productus, Spirifer, Athyris, Chonetes, Fusulina,* crinoid stems, &c., 1 to 15 feet thick.

Bed 5 of the above section furnishes very excellent building stone, which has been used in the fine dwelling of Mr. Dean and some others. It is very tenacious but soft, easily cut with a knife, can be smoothed with a common jack-plane, so that it makes excellent caps and sills. One special virtue in this rock for building is that it never sweats, that is, moisture never accumulates in the walls. So that a house built of it is dryer even than one of wood. Ashland is the county seat of Saunders County, and is very favorably located for a flourishing village. It is surrounded by a fertile and productive country, and the water of Salt Creek has become so freshened by the time it reaches this point that cattle are not affected by it, but rather prefer it. All kinds of building material are abundant everywhere, and wood in moderate quantities. Farther westward the exposures of the basis rocks are very rare; occasionally a little stream will cut down into them. On Skull Creek the gray arenaceous shaly marls of No. 3 appear near the bed of the creek. The upper part of the bed is about one foot, of yellow or whitish-yellow limestone; over it is a considerable thickness of coarse, loose sand, much of it worn down from the Cretaceous sandstones of No. 1. In the manufacture of artificial building material this might be made very useful. A little higher up on this creek I found a man digging for coal. A layer of shale, which possibly represents No. 2, deceived him into the belief that coal must exist near. He passed through a bed of chalky marl with abundant specimens of *Inoceramus problematicus*, then a marl that disintegrates so rapidly on exposure. Along the Platte River, on the south side, about fifteen miles below the mouth of Loup Fork, there is a cut bank which exposes the following beds, which belong to the post-Tertiary, but which I regard as older than the yellow marl:

2. Three feet soil; 1 foot yellow marl with pebbles; 10 feet sand, gravel, and rounded granite boulders.
1. Black ash-colored plastic clay, 25 feet.

There is a line of separation between beds 1 and 2, that seems to indicate a break or interval of time; at any rate the materials change most abruptly. The clay bed below has much the appearance of the dark Cretaceous clays, but is full of small, water-worn pebbles, with now and then a rock of considerable size. I am inclined to the opinion that this clay will be made very useful for many purposes, but more especially for the manufacture of pottery. The geology of Nebraska, south of the Platte River, may be summed up as follows: The first two tiers of counties are underlaid by Carboniferous and Permian rocks; overlapping these in the third tier west, are the Cretaceous sandstones of No. 1, then No. 2 and No. 3, and possibly Nos. 4 and 5, but it is probable that the latter beds are not seen; but about thirty miles above the entrance of the Loup Fork the Cretaceous belt is overlapped in turn by Tertiary beds, and then continue uninterruptedly to the western limits of the State. We have, therefore, but these three portions that can be colored on the map. The simplicity of the geological structure of Nebraska south of the Platte can be seen at a glance, and I have perhaps devoted in this report all the attention to it which it deserves. The superficial deposits of that region are more difficult to study and require more attention than I was able to give them. They will be treated of more fully in the account of the geology of Nebraska north of the Platte.

CHAPTER VI.

GEOLOGY OF NEBRASKA NORTH OF THE PLATTE.

With the exception of a small portion of Douglas and Sarpy Counties, bordering on the Missouri and Platte Rivers, the whole State of Nebraska north of the Platte River is underlaid with rocks belonging to two geological eras, Cretaceous and Tertiary.

The Cretaceous rocks make their appearance in their eastward extension in rather thin beds, capping the summits of the hills, and only the more compact layers, resisting the eroding effects of water or atmospheric agencies, remain to indicate its boundaries and extent. I am inclined to the belief that the rusty sandstones of the Dakota Group once extended in full force directly across the Missouri into Iowa, and that the sandstones recently discovered by Dr. White on the Nishnabotna River form a portion of the series, disconnected only by the wearing away of the intervening rocks. There is no doubt that a great portion of northwestern Iowa is underlaid by rocks of the Dakota Group.

The green color on the geological map of Nebraska connected with this report will show the eastern boundaries of this group with accuracy. The Carboniferous limestones soon begin to disappear north of the Papillion River.

At Sarpy's old trading post, near Bellevue Landing, some thin layers of rock occur in the hills, and a thin seam of coal has been found, and at low water two or three layers of rock are revealed, which can be made useful for building purposes.

At Omaha five to ten feet of limestones are revealed near the water's edge. The rock is quarried to considerable extent; but from the fact that Omaha is almost entirely supplied with rocks and lime for building

purposes from the Platte, we may infer that the quarries at Omaha are not extensive. The cost of stripping the vast thickness of superincumbent Drift and Loess at Omaha must render the working of this quarry very expensive.

The next exposure is at Florence, where the limestones are seen only at low water.

The last exhibition is at Rockport, near De Soto, where at very low water the limestones are seen at the edge of the river, but at neither of the localities above named are there quarries of any special value.

Along the Missouri bluffs there is no exposure of the underlying rocks again until we reach Tekama, Burt County. Here the nuclei of all the hills are sandstones and clays of the Dakota Group. From Florence to Tekama the bluffs or hills bordering on the Missouri are very rugged and high, but are composed entirely of Drift gravel at the bottom, and a great thickness of yellow marl at the top; indeed, this yellow marl or Loess is not unfrequently 50 to 100 feet in thickness. It is so soft and yielding in its nature that the little temporary streams flowing down the bluffs wear out immense gorges 100 to 150 feet in depth. The sides of these hills along the Missouri bottom, on the Iowa as well as Nebraska side, are often very deep, with angles of descent of 30° to 40°, and I have seen vegetation clinging quite thickly to their sides, when the descent was 50° to 55°, although the great geographer, Ritter, says that the grade at which it is possible for earth to cling is 45° At Tekama are some exposures of the sandstones of the Dakota Group, but mostly so soft and friable as to be of little value as building material.

In the absence of all other rocks the inhabitants quarry out the harder portions and use them. Underneath the sandstones are the usual variegated clays and sands, red, white, gray, and drab, with nodules of the sulphuret of iron. In the sandstones above, there is quite a variety in the texture of the rock. Sometimes there are thin intercalations of clay; then little pockets, as it were, of clay inclosed in a thin shell of iron; then the thin layers are oblique, as if the waters in which the sands were deposited were in currents, or in a disturbed condition. Indeed, it would hardly be possible to describe all the varied conditions which this rock presents. Between Tekama and Decatur, a distance of about sixteen miles, there are frequent exposures of the sandstones and clays, but none worthy of special notice until we reach the vicinity of the little town of Decatur, near the border of the Omaha reserve. Here some harder layers of rock are exposed, which are used for the foundations of buildings and other economical purposes. There is one layer of quartzite.

The range of hills, all the way from Tekama to Decatur, is well grassed over, and very abruptly steep. Numerous springs of the purest water flow from these hills at all elevations. One of them is quite remarkable, and is known as the Golden Spring, from which quite a stream flows through the coarse sand. The time must come, in the future, when this will become a popular watering-place for the West. Above Decatur the Missouri cuts the bluffs so as to show a mural escarpment as follows:

2. Massive yellow marl; no lines of stratification visible; immense masses slidden down, several yards having fallen in, 40 to 50 feet.
1. Variegated clays, with a soft, fine grit; there is a dark seam in it filled with bits of coaly matter.

These clays vary from a purplish hue to a dark drab; 100 to 200 feet exposed here. A little farther up the river the soft yellow sandstone

appears above the clays in regular order. There are great quantities of iron ore, a kind of limonite, scattered all along the river in large flat or irregular masses, also some nodules or concretions. Another section, near the last, shows the following succession of beds:

4. Yellow marl, with small calcareous nodules; no stratification; 10 to 20 feet.
3. Yellow and gray indurated clays; 8 to 15 feet.
2. Soft, yellow, rusty sandstone, massive, with very little sign of stratification; 50 feet.
1. Variegated clays; 50 to 60 feet.

The rusty-yellow color prevails everywhere, arising from the oxydation of the iron. This gives complexion to everything in this formation. These different sandstones extend from a point near Florence, where they cap the hills above the mouth of Iowa Creek over one hundred miles. The fossil plants in the hills near Decatur, and at the Blackbird Mission, are very numerous; about fifty or sixty species have already been collected at these localities. The sandstone is quarried out and used for cellar walls, and for other purposes where stone is needed. It is useful, inasmuch as all other rocks are absent. Sand for making the patent concrete is exceedingly abundant. Near Tekama and Decatur there are thin seams of iron ore, which, when broken with a hammer, give forth a sound much like that from old pot-metal. It is really pretty good iron ore, but silicious and impure; and even if this ore were of the best quality, and in great abundance, there is no fuel in the country to render it of any value.

At the Blackbird Mission, on the Missouri, eight miles above Decatur, the bluffs of sandstone are quite conspicuous, and often present very high mural fronts, upon which the Indians have carved many rude pictures, doubtless portions of their hieroglyphical history. At this locality are quite numerous layers, from 1 to 4 feet thick, of a very compact, massive quartzite, the hardest and most durable rock in the State. It has the appearance of a metamorphic rock, so very hard and close-grained is it. The harder portions have been quarried out and used for the construction of a very large three-story building for the mission school.

As the construction of several railroad bridges across the Missouri are contemplated, no rock in the State would be so unyielding and durable for abutments as this, providing enough of it can be found. It seems to assume a concretionary form in the sandstone, and is of very uncertain thickness and extent. About two miles above the mission, the hills are cut by the river so as to reveal vertical bluffs, the rocks of which, in the distance, have a yellowish-white appearance, and from this fact are usually called chalk bluffs. The sandstone is massive, almost without stratification, and very friable and soft.

4. Yellow marl, recent, 10 to 50 feet.
3. Eight inches of earthy lignite, resting upon 12 inches of yellowish-drab arenaceous clay, underlaid by 8 inches impure lignite.
2. Massive yellow sandstone, with some thin intercalations of clay, soft and friable, readily yielding to the erosive effects of water, 60 to 80 feet thick.
1. Yellow, plastic, unctuous clay, toward the top becoming a grayish-blue; contains flat argillaceous concretions, 2 feet.

This is perhaps the finest and largest exposure of the rocks of this group along the river. The mural exposures of soft sandstone present good surfaces for the Indian to make use of to write his rude his-

tory, and on the chalk bluffs there are many of these hieroglyphics in positions totally inaccessible to the Indians at the present time. None of them now living know anything about them, and it is supposed that they must be very ancient, and that since they were made great changes must have been wrought in these bluffs by the waters of the Missouri. These markings are at least 50 feet above the water, and 50 feet or more below the summit of the bluff, so that they must have been made before the lower portion of the bluff was washed away by the Missouri. It seems strange that none of these hieroglyphical writings, which occur quite often on the chalk rocks of the Niobrara Group higher up the Missouri, are known to any Indians now living. Manuel's Creek is called in the Dakota language, the creek where the dead have worked, on account of the markings on the rocks.

The above illustration conveys an idea of the sandstones of the Dakota Group, as they front the Missouri, and shows the wearing away of the material of the rock underneath during high water. This erosion is continued for a series of years, until the superincumbent rocks fall down and are washed away by the river. Near the mouth of Omaha Creek are some very high vertical bluffs of sandstone, from which some rock has been taken for building purposes. It is useful, since no better can be found in the vicinity. For a considerable distance along the hills opposite Sioux City, beds of the gray quartzite are found, which are worked to considerable extent, and furnish a very good supply for the inhabitants. A few impressions of plants and a few fossil shells were found here. Near Sioux City, on the Iowa side of the Missouri, is a high cut bluff extending to the mouth of the Big Sioux River. Here was formerly a large exposure of the rocks of the Dakota Group, and these rocks exhibited well their variegated texture and composition. The color seems to differ, depending upon the amount of ferruginous matter in them. Only about 20 feet of the different layers are exposed, and only about 5 feet hard enough for building purposes. This quarry has been wrought for twelve years or more, and at this time seems to have given out, for very little suitable building stone can be found, mostly loose sandstone and clay. In former years I have obtained impressions of dicotyledonous leaves, as willow, laurel, &c., with some fossil shells of the genera *Pharella*, *Axinea*, *Mactra*, and *Cyrena*, which are in part estuary and in part marine in their habits.

Near the northern boundary of the Omaha reserve traces of a whitish, chalky limestone, almost entirely made up of the shells of a species of *Inoceramus*, make their appearance on the high hills. This rock indicates the first appearance of the Cretaceous division, No. 3, or the Niobrara group.

In passing northward, as we continue up the Missouri, we find this formation becoming more and more conspicuous, until opposite Sioux City it is 50 to 100 feet in thickness. It is of much value to this region of the country, on account of its qualities as a material for lime, and it supplies a large district with that valuable material. Omaha is largely supplied with lime from the region of the Platte. Between Omaha and the northern boundary of the Indian reservation, a distance of eighty miles or more, extending southward to the Platte, near Columbus, there are five or six counties entirely destitute of limestone. This limestone of the Niobrara Group becomes very valuable, therefore, and it will be from this upper district that the counties underlaid by sandstones of the Dakota Group must obtain their supply of lime. Number 2, or Fort Benton Group, seems to be wanting until we reach a point near the mouth of Iowa Creek. This is a thin bed, not over 40 feet in thickness at any

one point, and is characterized by black plastic clay filled with beautiful crystallized sulphuret of iron. It is pretty well exposed below the mouth of Iowa Creek, where the Missouri cuts the bluffs, and here we see all the rocks in their order:

4. Yellow marl, a recent deposit.
3. Niobrara Group, layers of white and yellow chalky lime, passing down into gray marly rock.
2. Black plastic clay, with hard layers, containing *Inoceramus*, a species of *Ostrea*, like *O. congesta*, remains of fishes, many crystals of sulphuret of iron, selenite, &c.
1. Dakota Group, sulphuret of iron, fragments of wood, impressions of leaves, willow, laurel, &c.

Near the mouth of the Niobrara River the black shaly clays of the Fort Pierre Group begin to make their appearance on the hills over the Niobrara Division, so that within the limits of Nebraska proper we have four out of five of the important divisions of the Cretaceous rocks of the west.

Near the mouth of Iowa Creek there seems to be a bed of impure lignite in the Fort Benton Group, or in the transition between the Dakota and Fort Benton Groups. This bed, which has been worked to a considerable extent, and the coal used by blacksmiths in this vicinity with some success, does not seem to be the same as that seen along the Indian reserve, which is undoubtedly in the sandstone of the Dakota Group.

I am inclined to the opinion that this bed of lignite near Ponka City is a local bed, or at least restricted in its geographical extent, and is the result of an accumulation of drift-wood in an estuary of the Cretaceous sea. I am informed that it is seen over on the Elkhorn River, about thirty-five miles west of this point.

Mr. Clark tells me that he dug 12 or 15 feet below this bed, and struck another seam of coal much better than the one cropping out. The lower bed must be the one in the Dakota Group. Lithologically, it is impossible to draw a line of demarkation between these formations here. No. 1 passes so imperceptibly into No. 2, and No. 2 into No. 3, that there is no break, and yet their principal characteristics are very distinct. The first is a sandstone; second, a black, plastic clay; third, a chalky limestone; and yet I cannot tell the exact point where one commences and the other ends.

The impressions of leaves have ceased to appear before the close of the Dakota Group. The sandstones of the Dakota Group occupy the whole country along the Platte from the mouth of the Elkhorn to a point some twenty miles beyond the entrance of the Loup Fork.

The intermediate counties between the Missouri and Platte have very few exposures of rock of any kind, so that quarries in this region, even though the rock is of inferior quality, are much prized. We have, therefore, within the limits of the State of Nebraska north of the Platte, the Carboniferous rocks underlying two counties—Sarpy and Douglas; then come the Cretaceous rocks, especially No. 1, overlapping the Carboniferous. These beds continue along the Missouri to the northern limit of the State. They extend in a southeastern direction beyond the south line of the State into Kansas, underlying a belt of country from fifty to two hundred miles in width. About the sources of the Loup Fork, and about thirty miles west of Columbus, the Tertiary beds begin to make their appearance, and then extend to the extreme western limits of the State. Even along the Platte, before reaching Columbus, their

influence is felt to considerable extent, for the soil of the bottoms is quite sandy, and in some places too much so to be productive. The area drained by the Elkhorn and its branches cannot be much less than from two thousand to four thousand square miles, and yet over this large surface there are but few outcroppings of rocks of any kind. We know that the Cretaceous beds underlie nearly or quite all of it, and yet they seem to have yielded so readily to atmospheric influences that the surface is very gently undulating, the slopes along the streams being grassed over down to the water's edge. Along Elkhorn or Logan's Creek there is a bottom of greater or less width on either side, so that the basis rocks are concealed along the banks by a moderate thickness of superficial marl, a great part of which is composed of the disintegrated materials of the Cretaceous or Tertiary rocks. Over all this region there is very little timber, but the clays for making artificial building materials are without limit. The soil is wonderfully fertile, the water very pure, climate healthy, so that we cannot but believe that all this district will eventually take the highest position as an agricultural and grazing region. West of latitude 99° the Tertiary beds prevail to the exclusion of all others; the soil is less fertile, water and wood is less abundant, and yet the surface is covered with a thick growth of grass and other herbaceous vegetation. Although this portion of Nebraska cannot be cultivated successfully at this time, yet the climate is so healthy and the water so pure, the grass so abundant and nutritious, that it seems to me it will become in the future an excellent grazing region. The character of the surface, and the shortness, as well as the nutritious character, of the grass, would seem to adapt it especially for the raising of sheep, and immense herds of them might be raised by a pastoral people. The Union Pacific Railroad will transport all the products of this vast region to market, and I am convinced that even the sand-hills will yet become a fine pasture ground for herds of sheep, cattle, and horses, and thus every part of the State may be settled and made productive.

CHAPTER VIII.

THE COAL-FIELDS OF COLORADO.

I have endeavored in this chapter to take as complete a view of the Lignite formations of the West as the facts will admit, first confining my observations to the country west of the Mississippi, and then endeavoring to trace them beyond those limits. If the lignites of the West prove of economical importance, as we believe they will, they will be of inestimable value to all parts of the West, but to no portion more than to the State of Nebraska, and the time is now fast approaching when their true value will be determined. It is on this account that I give them so much attention in this report.

Although our knowledge of the Lignite formations of the West is not very extensive at this time, yet the discovery of them is by no means a new one, for they have been referred to in most books of travel since 1800. Lewis and Clark saw beds of "stone-coal" all along the Missouri. Wyeth says that the banks of the Yellowstone, below the mouth of the Big Horn, are in many places precipitous, with strata of "bituminous coal," and Captain Bonneville saw "anthracite coal" on Powder River. We now know that all these coal-beds are of Tertiary age, and cover a vast area bordering on the Missouri River. In 1842 Colonel Frémont

observed the lignite beds on some of the tributaries of the Columbia, and Green River, a branch of the Colorado. This is undoubtedly a western extension of a portion of the formations described on the Medicine Bow River. Near longitude 122° and latitude 45° 30′, Colonel Frémont discovered a stratum. (Frémont, page 192.) On Muddy River, in longitude 111°, and latitude 41° 30′, he found a most interesting locality, with several beds of coal and clay, and in one bed of indurated clay was a great abundance of vegetable remains. The stratum containing the plants was about 20 feet thick, and above it were beds of coal, each 15 inches thick; below are three beds of coal, separated by layers of clay. Captain Stansbury, in his report of an expedition to Great Salt Lake, frequently notices the existence of coal in numerous localities. On a fork of Bitter Creek he saw a stratum 10 feet thick, exposed for 100 yards. During the whole day's travel coal was exposed in every favorable locality. The dip of the beds was northeasterly 5° to 10°. All along the Muddy it also outcrops, even to the summit, where the waters flow each side into the Pacific and Atlantic. On Rattlesnake Creek were indications of coal, also on Sulphur Creek, of so good quality that he calls it stone-coal. In his report he says: "Specimens of it, although much weathered, burned in a camp-fire with a clear, bright flame. It is bright black; but when cut with a knife, appears dark brown; and when weathered, light brown. It is superior brown coal."

Mr. Henry Engelmann, in General Simpson's report, 1859, observed the Utah and Western Colorado coal beds in numerous localities. He regards the coal strata at Fort Bridger and beyond of Cretaceous age. On Sulphur Creek he found extensive coal beds with fossils, identical with Professor Hall's *Turbo paludinæformis*, from Muddy Creek. Captain Gunnison noticed coal-beds near the junction of Grand and Blue Rivers, in the Green River Valley; also on the eastern slope of the Wasatch Mountains, near the head-waters of Sevier River; also in the upper portion of the San Pete Valley, a stream which has its source in the eastern slope of the Wasatch range. This coal was used by the blacksmiths at Camp Floyd, and regarded by them as a superior "bituminous coal." Engelmann found the lignite all along Weber Creek, from Echo Cañon to Kamas Prairie. As this last locality is apparently in the midst of the mountains, Mr. E. speaks of the great tilting up of the beds. He also found fossils on Sulphur Creek that appear to be identical with those discovered by Colonel Frémont on Snake River, longitude 115°, latitude 43°, overlying a sandstone which contains in the greatest abundance an ostrea (*O. congesta*, probably) and *Inoceramus*, (*I. Crispii.*) The sandstone was white, rather soft and fine-grained, and undoubtedly represents No. 3, or the Niobrara Group of Cretaceous rocks. At the forks of Sulphur Creek the whitish sandstone occurs again, with *Ostrea*. Near the crossing of Sulphur Creek is a spring of petroleum, which has been referred to by several former travelers. Shallow depressions in the ground near the spring are filled with water, and rising on the surface is the oil or tar. The Mormons and other emigrants employ it as a liniment for wounds, and as a lubricator for their wagons. On exposure to the air it is changed from a green color to a dark brown, and it has an aromatic taste. This tar hardens as it flows from the ground, and becomes mixed with the soil around the sides of the spring. In 1860 I noticed the same phenomena in several places along the eastern side of the Sweetwater Mountains, and I was informed of the occurrence of these springs in many other localities. On Weber River, above the mouth of White Clay Creek, the *Ostrea* was found in several places in the *white sandstones*. Some specimens of coal have

been found in Round Prairie, on the Timpanagos, and the little stream near this point has been called on that account Coal Creek.

Colonel Emory, as far back as 1848, speaks of the occurrence of coal between Bent's Fort, on the Arkansas River, and Santa Fé, to the north and south of Raton Pass. A few specimens of dicotyledonous leaves were obtained, which indicate that the age of the rocks in which the lignite is found is Tertiary. I have thus far noticed the existence of this coal over districts which are about to be rendered more valuable by the construction of the two Pacific railroads, covering an area between the 48th and 38th degrees of latitude. I shall refer again in another portion of this chapter to the geographical extension of these beds beyond these limits.

After having examined with some degree of care most of the settled portions of the State, I regarded it as my duty to pass beyond its limits into the neighboring Territories in the vicinity of the Rocky Mountains to ascertain the quantity, as well as quality, of the lignite which was reported to exist there. The construction of the Union Pacific Railroads has created a new demand for mineral fuel all over this portion of the West, and if these great deposits can be made available, their value in the future development of the West can not be overestimated. By the kindness of the managers of the railroads I received free passes for myself and party, and thus was enabled, with comparatively little expense, to go beyond the first range of mountains, into the Laramie Plains, and returning by way of the overland stage route to South Boulder Creek, thence northward to Cheyenne City, along the base of the mountains. Along the line of the Union Pacific Railroad the limestones of the Upper Coal-Measures extend from Omaha to the north of the Elkhorn River, a distance of about thirty miles. Before reaching this point westward, however, the rusty, reddish sandstones of the Dakota Group are seen on the summits of the hills, gradually increasing in thickness and importance, until at the mouth of the Elkhorn, and for some distance up that stream, it forms moderately high, bluff banks. The railroad then descends into the Platte bottom, which is very wide, and the yielding nature of this formation, as well as the other divisions of the Cretaceous, causes the gentle slopes and the almost entire concealment of all the underlying rocks. From the mouth of the Elkhorn River to a point at least one hundred miles west on the Platte and Loup Fork, indications of the white chalky limestones of the Niobrara Group are seen, with the ever present *Inoceramus*, but there are no prominent exposures, and this rock, although excellent for limestone, is not found in sufficient quantities to be of much economical value. In 1857 I observed an exposure of soft, rusty sandstone at the mouth of Loup Fork, which belonged undoubtedly to the Dakota Group, but this year I was unable to find the locality again. It is safe to say that the Cretaceous beds extend up as far as the mouth of Calamus Creek, but all the underlying rocks in this region seem to be concealed from view by a thick deposit of yellow, sandy marl. The Tertiary beds commence overlying the Cretaceous rocks near the south portion of the Pawnee reservation. The exact position and age of these beds, as they first appear, I cannot tell, but they must be Upper Pliocene, or perhaps, indeed, of the age of the yellow marl or Loess. Near latitude 99° some small bones were found, which indicate the true Pliocene, and from there to the foot of the mountains the unmistakable Pliocene Tertiary beds prevail. So far as any evidence that I have yet been able to obtain, the Upper Pliocene beds shade off into the Loess in such a manner that I have seen no locality where I could detect any break in the continuity.

At Cedar Bluffs the yellow arenaceous marl is 100 to 150 feet thick, filled with shells of recent species, and this marl diminishes in quantity as we proceed, until the true Pliocene beds are visible. At Fort Kearney the Tertiary beds are quite conspicuous, forming high, rugged hills on either side of the Platte. The bottom of the Platte varies somewhat in width from five to fifteen miles, but, for the most part, is very level, while the hills which border it are rugged or smooth, depending on the character of the underlying rocks. Sometimes, for miles, they will present softened, smooth outlines, clothed with grass, without a rock in view; then, again, they will be cut up into ravines, and from the sides will project thick walls of sandstone or marl. At Julesburg the sand-hills form a somewhat conspicuous feature. The soil of the bottoms is so mixed with this floating sand that it seems hardly possible ever to make any use of this region for agricultural purposes. From Columbus to Fort Kearney there is little or no hard rock for building purposes, but from Kearney to the North Platte two or three moderately-thick beds of a fine, gray, calcareous sandstone, which, though soft and porous, might be made useful in the absence of any other materials for building purposes. The bottoms below the junction of the North Platte are quite fertile, yielding from one and a half to two tons of hay to the acre. After passing beyond the junction of the North Platte, the sterility and aridity increases until the sand monopolizes most of the country. This sand is mixed with small, water-worn pebbles, grains of quartz, flesh-colored feldspar, &c. Near Sidney Station the hills on either side of Pole Creek are quite high and rocky, and the rock is used by the Union Pacific Railroad Company for the foundations of the buildings at the station. There are several beds of this rock, varying in texture from a fine-grained sandstone, with some water-worn pebbles, to a flesh-colored, marly limestone. A bed of reddish, flesh-colored, indurated, arenaceous clay is also conspicuous. The soil is everywhere from 1 to 2½ feet thick, and sometimes from 6 to 8 feet thick. The summit is formed of a bed of marly sandstone 10 to 20 feet in thickness, and large masses of the rock have been detached and fallen down the sides of the hill. The lower part is composed of a light yellow, indurated marl. A few bones have been found in the rocky, as well as the more yielding beds of this locality, but they were not sufficiently characteristic to be determined specifically. But there is one interesting feature of this region which is worthy of notice. Through all these rocks there is more or less silex in various forms. It sometimes assumes the purer forms of chalcedony, and is found in great abundance, forming specimens of considerable beauty. The Indians, in ancient times, would gather this flinty rock into certain localities, and there manufacture their flint arrow-heads, knives, chisels, &c. Around Pine Bluffs is an abundance of these chipped flints, with broken arrow-heads, &c. These more recent Tertiary beds are a portion of the great basin to which the "Bad Lands" properly belong, but they do not always present those rugged features which are characteristic between White and Niobrara Rivers. Now and then there will be a small area which will remind one of those wonderful "lands," and the strata exposed give evidence of the age and their relation to the White River beds. On the North Platte are several localities that form landmarks, as it were, which are of very great geological interest. Nowhere, except close to the base of the mountains, are there any dislocations of strata or any evidences of upheaval, and where there are any hills, or "buttes," as they are called in the West, shooting their summits above the surrounding country, we know that they are monuments *of the past* which show that the surface of all

the country was once on a level with the summits of those high hills at least, perhaps much higher, for we cannot tell how much the summits have suffered erosion; we only know that the beds are horizontal up to the summit, and that there are fragments of beds which we never see elsewhere. The Court-house and Scott's Bluffs and other well-known localities are examples. The soft, marly nature of the rock causes it to yield readily to atmospheric agencies, and it is thus worn into the most fantastic forms, often giving to the scenery a wonderfully picturesque beauty. Near these localities have been found numerous specimens of fossil turtles and teeth, and bones of extinct animals. Some of them were of enormous size, and probably belonged to the huge species of Elephas (*E. imperator*), whose remains are so abundant in the Pliocene beds of Niobrara and Loup Fork. It would seem, from the organic remains found at various localities along the North Platte, that the Miocene beds of White River, and the Pliocene of the Niobrara, were represented there.

The formations along the North and South Platte will need a more careful study than I have been able to give them yet, before the details of the geology can be written with certainty. We know, however, in a general way, that all the rocks are of Tertiary age. The excavations made for the Union Pacific Railroad, along the valley of Pole Creek to the foot of the first range of the mountains, always reveal the marly beds of the Tertiary, varying in color from a chalky white to a deep reddish flesh color; but the superficial deposits attract the most attention, because more easily seen. Low down, almost to the mouth of Pole Creek, the small water-worn pebbles are seen mixed to a considerable depth with loose sands and marls. These pebbles increase in size as we approach the mountains, and all along the eastern slope are well-worn boulders, 3 or 4 feet in diameter, and the cuttings for the railroad show that they extend down to a considerable depth. What relation this superficial deposit of boulders, sands, and marls bears to the Tertiary beds beneath it is difficult to determine without a more thorough examination; but that it is connected with the latest period of upheaval of the Rocky Mountain range there can be scarcely room to doubt. I shall discuss this subject in another place.

From Omaha to Cheyenne City, five hundred and twenty-five miles, the ascent is quite gradual but persistent. According to the observations of the engineers of the Union Pacific Railroad, which were made with great care, Omaha is 925 feet above the sea level, while Cheyenne City is 5,085 feet, averaging a little over 9 feet ascent to the mile. This point is regarded by the railroad company as the base of the mountains, and here some of their most expensive buildings will be erected. The city was laid out into lots in July, 1867, and by December of the same year there were from 2,000 to 3,000 inhabitants, with some very costly and substantial buildings. Such cities, springing up all along the line of the road, at once called into demand all the resources of the country, and the search for building materials, fuel, &c., has commenced in earnest. Although the resources immediately around Cheyenne are not extensive, yet at a distance of not over twenty miles into the Laramie Mountains timber is moderately abundant, while the best of building materials, in the shape of stone, are found on every side. Even around Cheyenne some of the marly Tertiary sandstones are found to be sufficiently hard and durable for houses, and General Stevenson is erecting a large warehouse of this rock. It is used to a great extent, and will probably be found to answer all practical purposes, though entirely devoid of beauty. Some of the beds of Tertiary marl are found to contain so large a percentage of lime that it is burned, and is thought by

some to be of excellent quality; but it has a dirty appearance and does not make a clean wall. Near the margins of the mountains there are some of the finest beds of limestone in the West. The rock itself is nearly white, and when burned in a kiln produces a lime that is as white as snow, and the walls of houses prepared with it present a most cheerful, light appearance. There is the greatest abundance of these rocks; these carboniferous limestones sometimes attain a thickness of 1,000 to 1,500 feet. The roads up to the margins of the Laramie Mountains are excellent, and the ascent is gradual, so that transportation is comparatively easy. From Cheyenne to the summit of Laramie Mountains the distance is about twenty to thirty miles, and the elevation is 7,297—an increase in the ascent in this distance of nearly 90 feet to the mile. From Cheyenne to the summit of the mountains the railroad passes up a ridge which is quite remarkable, and seems especially adapted to the location of this great national road. On either side for many miles no such range can be found, rising gradually, as it were, to the very summits, without any of the abrupt, rugged places which are so common everywhere along the margins of the mountains. Usually there is a deep valley scooped out by glacial action all along the immediate base of the mountains, which would prove a serious obstacle in the building of a road, but here, for a belt of five to fifteen miles in width, this erosive action seems to have been checked for the time, leaving one of the most remarkable inclined planes I have ever seen along the mountain slopes. The basis rocks are unquestionably Tertiary, probably later Pliocene, but scattered all over the surface are many water-worn boulders, and the cuttings of the road reveal a considerable thickness of superficial material filled with worn rocks of every size and variety, most of them evidently having their origin in the nucleus of the mountains. The rocks which compose the true Tertiary beds seem changed here. All the hard strata are formed of an aggregation of crystals of quartz, feldspar, and small, water-worn pebbles, making a kind of pudding-stone, and interstratified are these layers of whitish and yellowish clay, loose sand, or marl, the whole indicating a deposition in disturbed waters. This deposition must have taken place here also after the Rocky Mountains had reached their present elevation, or nearly so, for these beds jut up against the inclined older formations, reposing unconformably on them. Indeed, in all the little valleys of the mountains, patches of these Tertiary beds may be found, sometimes resting high upon the margins, but in all cases nearly or quite horizontal. Farther north, about fifty miles above Fort Laramie, and near the Red Buttes, I have seen these beds dipping at an angle of 50°, showing that they partook of the last period of elevation. At another locality, near the margin of the mountains, at least 7,000 feet above the sea, a bed of Tertiary sandstone inclined eastward from the mountains 10°. These beds here are composed of materials more or less coarse; some layers made up of crystals of quartz and feldspar, with now and then a rounded pebble; sometimes loosely aggregated, then cemented into a firm rock; then coarse beds like conglomerate. These beds attain here a great thickness, evidently not less than from 500 to 600 feet. By examining the border lines between the Pliocene Tertiary and the Eocene coal beds, a little farther to the southward, it will be seen at once that they do not conform. This same want of exact conformability is seen all along the slope of the mountains to the South Pass. Near Carmichael's Camp, or Evans Pass, the older rocks appear from beneath the Tertiary, inclining in regular sequence from the mountain nucleus. The Carboniferous and the red or Triassic beds *are all that are* exposed to view. Just at this lo-

cality all the more recent formations, as Jurassic, Cretaceous, and Eocene Tertiary, are concealed by the immense deposit of recent Tertiary, yet all these formations are exposed in full force within a few miles on either side north or south of this point. Nowhere on either side of this range south of Laramie Peak was I able to find any rocks below the Carboniferous limestones and next to the metamorphic rocks that along the Wind River, Big Horn Mountains, and the Black Hills, I have hitherto called the Potsdam sandstone. A section along the upturned edges of the beds from the syenite nucleus would be as follows:

1. Light-gray, compact, siliceous limestone, 2 feet.
2. Reddish laminated sandstone, 10 feet.
3. Light-gray, limestone-like bed, 50 feet.
4. Fine reddish sandstone, 40 feet.
5. Light-gray, bluish limestone, 10 feet.
6. A reddish calcareous sandstone, 6 feet.
7. Light-gray limestone, 30 feet.
8. Reddish laminated sandstone, some parts quite soft, 20 feet.
9. Bluish limestone, 10 feet.
10. Reddish laminated sandstone, 10 feet.
11. Bluish, hard limestone, 15 feet.
12. Reddish laminated sandstone, 4 feet.
13. Excellent white limestone, with *Productus Prattenianus*, *Athyris subtilita*, &c., 150 feet.

The above section is given simply to show the lithological character of these Carboniferous beds, that the brick-red character is not continued to the supposed Triassic. The thickness stated is merely approximative. The whitish limestones are quite persistent in their characters, but the other beds are variable, sometimes massive or laminated, siliceous or arenaceous, bluish or reddish here, &c. The dip is also variable from 20° to 45° southeast. Looking from the top of the hills into the valleys below, we can see the white beds of the Tertiary jutting up against the older rocks, or in isolated patches high on the sides, easily detected by the eye far distant, by the numerous eroded surfaces. When the eye has become familiar with the lithological characters of the different geological formations it is easy to detect them even in the distance, and as far as the eye can reach the rocks belonging to the great Tertiary basins, the Miocene and Pliocene White River and Niobrara deposits, and the Eocene and Miocene lignite beds. The former always has a light color, and in almost all cases presents many eroded bare spots, which seem of a much lighter color in the distance, while the rocks of the latter basin always exhibit a brown, somber hue, each one possessing numerous characters which to the practiced eye are unmistakable. In 1859 I detected, through a glass, from the base of the Black Hills, some isolated ridges, thirty miles distant, which appeared to be the White River Tertiary beds superimposed on the lignite beds. Anxious, at that time, to show the relations of the two great basins to each other by actual contact, I rode to them and found them to be as I had conjectured, and thus I was enabled to solve the desired problem. Indeed, all the geological formations of the West possess certain lithological lineaments caused by the varied effects of atmospheric influences which are unmistakable to the practiced eye. As I have before remarked, no unchanged sedimentary rocks are seen in this region between the true Carboniferous and the metamorphic, and, consequently, we pass directly to the nucleus of the Laramie range. The principal rocks are syenite, and it presents *almost* every variety, from an exceedingly compact, coarse-grained mass,

almost destitute of hornblende, to a very coarse aggregate of quartz, feldspar, and hornblende, the large, reddish crystals of feldspar being the most conspicuous. Most of these metamorphic rocks contain considerable iron, probably originally in the state of sulphuret, which has caused the separation of the crystals of feldspar, and there seems to be all over the surface of the country on the summits of this range a heavy superficial deposit which is mostly made up of small masses of feldspar. When this material is abundant it forms the finest of roads, which are very smooth. This tendency to disintegration seems to characterize all the metamorphic rocks of this region, and thus they are often worn into some wonderfully fantastic forms. These massive granite piles are not uncommon all along the summits of the mountain ranges, and, standing so clear above the general level of the country, seem more like immense boulders transported from some more northern region. Yet these massive piles, while they do not seem to reveal any distinct signs of stratification, extend along the mountains in definite, rather narrow belts, with a course about northwest and southeast. The illustration given above shows the forms of these massive piles of rocks as they are seen in hundreds of localities. The evidence is quite clear that all the rocks which are exposed in this Laramie range are really stratified metamorphic rocks in nearly or quite a vertical position. Sometimes the seams are of trap or greenstone, then quartz or clay slate, extending in definite lines, and all parallel. The corners are still very sharp, as if time, which rounds off the hardest granite, could not affect this. It forms exceedingly beautiful and picturesque scenery, and must prove an elegant and durable rock for building purposes. Some of the massive piles of syenite near the sources of Dale Creek are very close-grained, and would, if polished, be almost as handsome for building purposes or monuments as the Scotch syenite. Mr. S. B. Reed, engineer of construction, Union Pacific Railroad, first called my attention to this fine syenite, and it is now proposed to transport this rock from the summit of the Rocky Mountains to Omaha to construct the piers of the bridge across the Missouri River. Again, these granite masses assume forms sometimes looking like a figure with its broad cap, then apparently just poised ready to tumble down into the ravines below, where thousands of similar masses may be seen which have fallen at different times.

Flowing among these hills are some of the purest streams of water that the mountains afford, well stocked with trout. Sometimes in the level, prairie-like portions of the mountains, these streams are so deep and the borders so boggy that it is difficult to cross them, and the dams of the beaver add to the difficulty; all through the mountains are thousands of beautiful valleys filled with springs and small streams, with a fine growth of grass; quite large, prairie-like areas, sometimes nearly level, or slightly undulating, dotted over with monumental piles of granite, syenite, gneiss, or slate. Continuous ridges, rising up in the prairie, are not uncommon, while the eroded or disintegrated materials, clothed with vegetation, so conceal the rocks sometimes for miles around that the country looks like a plain. Occurring quite frequently, but not as common as the syenite rocks, are stratified gneiss ridges which extend also across the summit of the mountains in definite lines. In most cases these rocks seem to be vertical, but sometimes they are inclined; but taken in the aggregate no dip in any particular direction could be obtained.

The timber in these mountains is mostly pine and spruce, but it is by no means abundant. There are no dense forests just along the immediate line of railroad. *The soil in these* mountains is excellent and pro-

duces a good growth of vegetation, but it is hardly probable that any attempt will be made to cultivate land so much elevated above the sea level. As we descend the western slope of the Laramie range into the plains, the brick-red beds which are seen on the eastern margin again appear, inclining westward. It is then evident at a glance that these beds are the counterparts of those on the opposite side, and that prior to the elevation of the mountains they extended without a break, and in a horizontal position over the area occupied by the metamorphic rocks. Even the moderately-thick covering of vegetation on the western margin, and extending far into the plains, cannot conceal the brick-red color of the earth beneath. This fact gives a singular appearance to the scenery, and as these red beds are gypsiferous, a white efflorescence covers the surface in low wet places in the dry season of autumn. This white material, which is most abundant everywhere throughout the Plains, is called alkali by travelers. These red beds seem here to rest directly upon a dull-red granitoid rock, which on exposure to the atmosphere readily disintegrates, so that there is a great thickness of débris composed for the most part of feldspar crystals. The Carboniferous beds extend down the western slope in ridges, as if the erosive power had acted in grooves or channels, leaving alternate valley and ridge. A section of one of these will include most of the beds visible here, and convey a pretty clear idea of their composition.

6. A compact, thin layer of arenaceous limestone, containing a species of *Orthis*, forms the summit, 4 feet.
5. Fine sandstone, easily disintegrated, with very irregular laminæ; a rather light-red rock, 100 to 150 feet.
4. Yellowish-white limestone, excellent quality, 2 feet.
3. Brick-red fine sand, with spots of white sand-rock; irregular laminæ of deposition.
2. Very hard, bluish limestone, filled with comminuted crinoidal remains, 6 to 8 feet.
1. Loose, brick-red material, gradually passing up into a brick-red, fine, compact sandstone, 100 feet.

The brick-red beds I have been accustomed to regard as Triassic, but it is evident that this color is not confined to them, but is also common to the Carboniferous rocks. The evidence seems to point to the conclusion that in this immediate vicinity the beds are of Carboniferous age, and that there are none of the true gypsiferous beds occurring here, on either side of the range. The disintegration of beds 2 and 3 produces the superficial red earth which covers so much of the Plains. The lower part of bed 1 is composed of loose, red material, with the seams of harder laminated rock, with one or two seams of gray, rather coarse-grained sandstone. The rock seems to be an aggregate of particles of quartz. This is to some extent a gypsiferous deposit, and it is not strange that the soil composed of the disintegrated materials of these beds should be alkaline. Bed 2 is a solid, massive limestone, composed almost entirely of fragments of crinoids, one of which was nearly perfect. This bed will be very useful for building-stone or lime. The inclination of the beds, as shown by these ridges, varies from 3° to 25°. But what adds much to the character of the scenery is the fantastic shapes these sandstones present through atmospheric action. Sometimes the ridges taper down to a point, the sides presenting the most rugged appearance, while the summits project in domes, columns, &c. Then again there are rounded masses, looking in the distance like *boulders*, and on near approach the well-furrowed sides can be seen.

This sandstone is much in use at Fort Sanders for the construction of houses. It works easily, and seems to be durable, but some of it must disintegrate too readily. There are portions of it, when quarried out, of a light-brown color, which do not seem to have been penetrated with the sesquioxide of iron. There are also, in the different layers, fine examples of waved surfaces.

The limestone has been used at the fort, and found to be of the best quality.

The Laramie Plains are surrounded with mountains as with a wall, and the scenery on a clear day is extremely fine. Along the west margin of the first or Laramie range the hills slope gently down into the plains, and are apparently lost in the level beyond. It is an important question to determine whether these plains can be cultivated with any success. That towns and cities will be springing up all along the line of this great national highway is already rendered certain, and much of the land has been taken by preëmption. General Gibbons made an attempt to raise garden vegetables in 1867, but he began too late in the season. In October, beets, lettuce, turnips, cabbage, &c., were still growing, and from the appearance of the vines I thought there were some good potatoes. Irrigation is required, and another season General Gibbon is confident of success. Fort Sanders is the most comfortable military post I have seen in the West. Fine streams of water are caused to flow all through the grounds, so that the best of spring water is at every one's door. About eight miles from Fort Sanders is a sulphur spring, which may eventually become of some importance. There are many other large springs in the plains. On both sides of the mountains, and about them, places of resort for health and pleasure will be erected at no distant day. East of the Big Laramie River the Plains seem to be covered with the débris of the red beds, and I looked in vain for some evidence of the existence of the Cretaceous rocks which should be represented. Near the Big Laramie Stage Station about 10 feet of black slate is exposed, which is evidently of the age of the Fort Benton Group. There were an abundance of fish scales and *Ostrea congesta*. This bed is exposed only for a short distance, and the strata are apparently perfectly horizontal. On the east side of the river, farther up about five miles, is a long ridge, which is formed of yellow arenaceous marl, with a layer 2 feet thick of rusty concretionary sandstone, with fish scales, sharks' teeth, and finely-comminuted shells, 30 to 50 feet in thickness. These Cretaceous beds seem to be lithologically like those that occur along the slope of the Big Horn Mountains, and they do not preserve their distinctive characters anywhere in the vicinity of the mountain ranges as well as on the Missouri River. The subdivisions are not always as distinct, yet it is hardly possible to mistake them. The ubiquitous *Ostrea congesta* always marks divisions 2 and 3 at localities however widely separated geographically. About four miles above the station, immediately along the river, a bed of yellow chalky shale was observed, in which well-defined specimens of *Ostrea congesta* were found, and its calcareous character showed it to belong to the Niobrara Group. The rusty layers on the east side, which hold a higher position, might belong to the Fox Hills Group. The layer of harder rock was a rusty, rotten sandstone, with some clay intermixed. Many of the high ridges that come down from the slopes of the mountains on each side of the river seem to be composed of Cretaceous beds, so that there is ample room for all the divisions to be represented. So far as I could determine, the Cretaceous beds extend about fifteen miles above on the south, and ten miles below on the north *of Fort Sanders, and on* the east side of the Laramie

River about five miles, so that the red beds slope down from the mountains and pass from sight directly under them.

About eight miles west of Fort Sanders, near the valley of the Little Laramie River, there is an exposure fifty feet or more in thickness of thinly-laminated shaly, light, rust-colored beds of the Niobrara Division, containing a great abundance of well-defined specimens of *Ostrea congesta*, in most cases attached to another large shell with a somewhat remarkable fibrous structure, observed long since on the Missouri River and in other places. This shell is here broken into fragments for the most part, yet the outline is seen complete, though it is quite impossible to procure perfect specimens of it. There is no doubt, however, that it is an undescribed species of *Inoceramus* of large size, sometimes a foot or more in diameter, to the smooth sides of which this little oyster seemed to have a strong tendency to attach itself. At the base of this exposure there is a dark-bluish, marly shale, which has the peculiar jointed structure of the Fort Pierre Group. These vertical joints run nearly northeast and southwest. Everywhere this bed is cut through in a remarkable manner by these vertical lines. All through these beds are seams varying from 1 to 6 inches or more in thickness, of calc-spar, often cutting the beds at right angles. There are also some apparently fibrous seams that are horizontal. Over the surface are abundant fragments of a rusty, argillaceous limestone, like that scattered over the cretaceous hills bordering on the great bend of the Missouri River, which would indicate the former existence of the Fort Pierre Group. On the summit of this exposure are layers of whitish, chalky rock, which is unmistakably No. 3, so that we may conclude that we find in the Laramie Plains certainly Nos. 2 and 3, and probably No. 4, of the divisions of the Cretaceous as developed along the Missouri River. There is another remarkable feature about this valley, as I have called it—that is, that it has no outlet. It is about two miles wide and ten or fifteen long, and has a drainage like the valley of some stream, and yet it has no connection with any permanent stream and ends abruptly at either extremity. Through the kindness of General Gibbons, commanding Fort Sanders, I was enabled to visit the coal fields on Rock Creek, a branch of the Medicine Bow, under the most favorable auspices. A few inches of snow had fallen the day before we left for Rock Creek which obstructed our examinations somewhat, but we obtained facts enough to show that there is here the eastern limit of a most valuable coal-basin, which will yet have a marked influence on the development of the West. The beds of lignite are exposed in hundreds of localities over an area at least forty miles in width and over two hundred miles in length. The report of Mr. Van Lennep, geologist to the Union Pacific Railroad, indicates more than fifty localities where good beds of lignite are exposed along the Medicine Bow River alone. And other facts show that we have here from 5,000 to 8,000 square miles of coal at least. It is only necessary in this connection to state the fact that this railroad is now being cut directly through the length of this great coal basin.

The first exposures that I saw of the coal were about eight miles west of Cooper's Creek. Here we found several beds, which seemed to have been brought to the surface by the upheaval of the mountains. The inclinations of the strata are from 5° to 25° at the opening, but gradually becoming horizontal as they recede from the mountain. The coal beds vary from 1 to 10 feet in thickness, and the coal resembles in its appearance the best quality of coals in Pennsylvania. In some of the beds are solid seams 2 to 6 inches in thickness, of a ma-

terial very like cannel coal, as if the vegetable matter of which it was formed was originally in a pulpy state. Even when taken from the outcroppings, where it had been more or less exposed to the atmosphere, this lignite burned quite well, with some draught. The interest in these fields, which the supposed future demand for fuel in this region has brought about, is very great, and large numbers of claims have been taken up. Iron ore is found also in the vicinity, but to what extent I could not determine. Stray fragments of the carbonate of iron have been washed down the valleys of the little streams from the mountains, and it no doubt exists in large quantities somewhere toward the sources of these streams. All these beds repose on well-marked Cretaceous rocks, and among some plants found in concretions in a bed beneath the first bed of coal seen, were a species of *Populus* and a *Platanus* apparently identical with those occurring on the Missouri river. As we proceed westward the coal formations become much more extensive, and a number of beds of coal are exposed. From the best information I could obtain exposures have been observed in a hundred places or more all the way to Great Salt Lake. A remarkable feature in this vicinity was the evidences of Drift or glacial action along the foot of the mountains. The Medicine Bow range extends nearly northeast and southwest, and all along the northeastern base broad deep valleys are scooped out, leaving lofty ridges sometimes broken and sharp at the top, 500 to 1000 feet in height, formed to a great depth of materials of various kinds, with different degrees of fineness, mingled with water-worn rocks, while the southwest sides are completely paved with rocks, some worn and others angular, as if the transporting power had been checked at the summit of the hill, and melting away, had dropped its burden on the summit and side of the hill. The opposite side is usually almost free from rocks, and not unfrequently reveals the basis formations as near Cooper's Creek, the rusty arenaceous concretions projecting from the sides of the hills were filled with a species of *Inoceramus* that indicate several hundred feet of the Fox Hills Group. After having made some brief examinations as far as Rock Creek we returned to Fort Sanders, and prepared to start for Denver, October, 1867, along the overland stage route over the mountains. Our course across the mountains was nearly southeast over a most excellent road macadamized with feldspar crystals. As we passed up the western slope the same red beds and layers of limestone as before described could be seen inclining at various angles.

Before reaching the summit also piles of rotten syenite occur. Far to the southwest the sharp snow-clad peaks of the main range could be seen, much of the time invested with clouds. A light snow had fallen the day before, adding much to the beauty of the scenery, but concealing the surface in most instances. The rugged piles of syenite, however, could be seen on every side, like monuments left after erosion. I am inclined to think that they are due to atmospheric agencies, and not to any local outbursts or upheavals, and that all these beautiful valleys which, like that of Dale Creek, have been admired by all travelers, are entirely due to the wearing away of the rocks by water. The soil is good, and the superficial materials or débris, as we may call the more recent deposit which forms the immediate surface, is quite thick. The vegetation which clothes the ground is quite abundant—grass, reeds, and smaller shrubs, but the larger trees are scarce over large areas. Along the northeastern margins of the Medicine Bow Mountains there are some dense forests of the Douglass spruce (*Abies Douglassi*), which is used extensively by the Union Pacific Railroad for ties, and it surpasses

all other timber for that purpose. These trees are often as straight as an arrow for 80 feet. They seldom attain a larger size, so that the logs are hardly large enough for lumber. Houses are built of it by sawing the logs into two portions, and laying the sawed side out, and thus some of the handsomest buildings at Fort Sanders are constructed. Pine is not uncommon, yet there are no dense forests of it, as we might expect in so mountainous a region. On the summits of the mountains it seems to grow low and scraggy, as if it drew but a scanty nourishment from the soil. In other localities it rises to the dignity of a forest tree 80 to 100 feet high, and has a trunk large enough for mill logs. The little cottonwood, quaking asp, alder, and some other small trees and bushes occur, but they are very thinly represented, and would furnish a very scanty supply of fuel. After passing the summit we descend into the most beautiful and picturesque valley along the overland route, Virginia Dale. Dale creek is a branch of the Cache la Poudre, and is composed of a number of branches ramifying through the mountains, filled with trout. The water is most pure and delightful to the taste. It is a curious fact that while some of the branches of the North Platte rise in the divide with those of the South Platte, yet not a single trout has ever been seen in any of the waters of the North Platte; while in every mountain stream emptying into the South Platte the trout are very abundant. I have regarded the cause of the absence of trout in the North Platte due to the existence of the great amount of alkaline matter all along its valley, which, mingling with the water, is destructive to the trout, but not to the ordinary kinds of fish. On either side of the road high mountain peaks rose like a wall, but in a southwesterly direction the beautiful mountain called Long's Peak, with the extensive and lofty range to which it belongs, could be seen. I found along the road in passing through this valley even to the Cache la Poudre, comparatively little rock, but the different varieties of syenite. In one instance I found some mica schist, but as a general rule mica is wanting. In Virginia Dale I found some high masses of the red feldspathic granite with small, thin plates of mica. This is the first true granite I have noticed. There are also thin seams of large crystals of feldspar. The granite here is elevated in huge piles with vertical and horizontal partings, so that it is separated into massive blocks 10 to 15 feet on a side in dimensions. This granite would be very durable for buildings—is not very coarse, although it is a mere aggregate of the three constituents. There are also dikes or wedges of hornblendic slate and greenstone, and seams of white quartz are not uncommon. Near Virginia Dale Station there is a huge massive pile of rock forming the side of the cañon of the stream 600 feet high. It is a coarse feldspathic granite, the feldspar predominating in large crystals of a reddish hue. Near Stonewall Ranch, on the east side of the range, there is an immense pyramidal pile composed of the red beds, which are nearly horizontal. At the base there is a whitish, gypsiferous sandstone, and from there, in ascending order are 350 to 400 feet of alternate layers of fine brick, red grit and harder red sandstone, the harder layers projecting out from the nearly vertical sides. These rocky layers vary from 1 to 10 feet, and the loose material 4 to 30 feet in thickness. These reddish rocks form a sort of wall along the road for miles. Near the summits are some beds of brown limestone like the limestone layers near Fort Sanders, and although I found no fossils, I do not hesitate to regard them as of Carboniferous age. This range of hills, after extending southeastward along the road for a mile or more, in a nearly horizontal position, commence, inclining 1°, then a *little farther* 5° to 7°. The direction of the dip is southeast again; the

dip is 14°, and still farther the whole series inclines 10°, 11° to 17°, and in some instances 30°. On the summit there is a bed of yellowish limestone resting upon the reddish sandstone, 10 to 15 feet, then above this a whitish limestone, then a bluish, hard limestone, 6 to 10 feet, all of which would make excellent lime. Farther down the margins of the mountains we pass over a great thickness, 1,000 feet or more, of brick-red grit beds, which are plainly gypsiferous, entirely destitute of organic remains, inclining at various angles varying from 15° to 24°. There seems to be no break in the continuity of the layers, at least none is perceptible to the eye; and, therefore, in the absence of fossils it would be unsafe to pronounce upon its age, but they are either a prolongation upward of the Carboniferous or possibly Triassic. Continuing our course eastward, we pass over a bed of light-gray, massive sandstone, 50 feet thick, nearly horizontal; above this there is a thin bed of greenish-gray, arenaceous marl, 15 to 20 feet in thickness, capped with a fine, rusty-gray siliceous rock, which occupies the position of the Jurassic beds farther north, and resembles them somewhat, lithologically. After searching with considerable care over a large area, I was unable to find even a trace of any organic body. On the east base, along the roads, and extending to Laporte, on the Cache la Poudre, we found a full development of the Cretaceous rocks. They seem to be 300 to 500 feet in thickness. No. 2, or Fort Benton Group, is well shown as a dark shaly clay, with seams of marly clay, containing *Ostra congesta* and an *Inoceramus* undistinguishable from *I. problematicus*. Below No. 2, which we will regard as a fixed horizon, is a bed of gray silicious grit, which may represent No. 1 or Dakota Group, or it may belong to the Jurassic. Although this bed is quite persistent all along the margins of the mountains, from the Wind River range to Pike's Peak, I have never yet been able to find a trace of any organic object, not even silicified wood. I have usually regarded this bed as No. 1, with a query. Above No. 2 we find a good thickness of No. 3, but becoming more arenaceous in its southern extension. Yet portions of it retain the same light color and chalky character as heretofore. Separating No. 2 from No. 3, there is a bed of light-gray sandstone, which gradually passes down into the plastic clay of No. 2. No. 3 contains the *O. congesta* and *I. problematicus* in considerable numbers. As we look eastward from the summit of the range toward the level prairie, the upturned edges of the different beds recede like waves of the sea until they die out in the plains. These ridges of upheaval, grow smaller and lower; the inclination is usually at a smaller angle until the beds that are exposed above the surface show no perceptible dip. It seems quite strange that no rock is to be found south of the Red Buttes that can be referred to the Potsdam sandstone. Along the Wind River and Big Horn range it is seen resting on the metamorphic rocks and charged with its peculiar fossils; but as we proceed southward it seems to disappear, so that, after leaving the central metamorphic portion of the Laramie range we pass over Carboniferous, Triassic? Jurassic? Cretaceous, and finally, in the plains, the Lignite-Tertiary. Before leaving this nucleus, however, we see an abundance of the hornblendic slates and other metamorphic rocks which occur in the principle ranges, showing the close proximity to the main crest of the mountains of which Pike's Peak, Long's Peak, &c., form a part. Somewhat extensive valleys occur between all the ridges of upheaval, varying from a fourth to half a mile in width, through which some little stream makes its way, usually. Sometimes, however, the rivers cut their way directly through these ridges, as is the case with Cache la Poudre. Nowhere south of Fort Laramie do we see those *massive beds of whitish* limestone that occur farther

north. Near the head of Deer Creek, about one hundred miles north of Fort Laramie, the Carboniferous rocks attain a thickness of 1,000 feet or more, composed of layers of massive limestone with hardly any tinge of red; but as we proceed southward the lime gives place to sand, and the color becomes more reddish, until even the thin layers of limestone are tinged with the red color. It is quite possible that this change is due to the decomposition of the sienite rocks, of which the nucleus of the Laramie range is mostly composed, and that these brick-red beds are formed of this débris. In these red beds are considerable quantities of silex, and in many localities the fragments cover the ground. This was the favorite material of which the Indians in former times fashioned their arrow-heads and knives. The distance from the plains across these ridges of upheaval to the nucleus rocks varies much at different localities.

At Laporte, on the Cache la Poudre, the distance is not more than a mile, and there are not more than three of these ridges. At a point about ten miles north, along the stage road, the distance is five to ten miles, with a dozen or more of the ridges of upheaval. At Cache la Poudre, Cretaceous beds form the low ridges, inclining 16° to 17°, the Jurassic, Triassic, and Carboniferous, two to three ridges, from 500 to 800 feet in height, and inclining 15° to 17°, with a strike about northwest and southeast. As we descend the Cache la Poudre River, we pass over the black shales of No. 4, and the rusty-yellow arenaceous rocks of No. 5 for about four or five miles, when they are overlapped by the Lignite-tertiary beds in nearly or quite a horizontal position. The soil along this valley is quite good, and by irrigation the farmers raise good crops. Two and a half miles south of Cache la Poudre the first conspicuous ridge is composed of Carboniferous rocks and inclines 25°, again a little farther, 21°. Near Thompson's Creek the road runs along the immediate base of the first hills of the range. Between the upturned edges of the Cretaceous and the slope of the red beds and Carboniferous rocks is a beautiful valley, about half a mile wide, worn out in a concave manner, with little side valleys coming into it from the western side. This valley was finely grassed over, and seemed more like a park walled in on either side. The Cretaceous beds formed two or three ridges inclining 5° to 8°, and finally sloping into the prairie, and passed under the Tertiary beds. Here also I found, in No.'s 2 and 3, *O. congesta* and *I. problematicus*, with numerous fragments of the fibrous shell of another species of *Inoceramus*. In the bed of a little creek No. 4 is well shown, dipping 15°. In a number of localities between Cache la Poudre and Thompson's Creek, No. 4 is revealed with a thickness of from 100 to 200 feet. These dark shales have been thoroughly prospected for coal, as is shown by the numerous excavations. Near this point is a fine exposure of No. 3, dipping in such a manner as to pass directly under No. 4. Without doubt No. 5 would be seen by proceeding eastward into the prairie a short distance before we come to the point of overlapping of the Tertiary beds. The truth is, all the divisions of the Cretaceous rocks of the west, with the exception of No. 1, are well developed all along the eastern flank of the mountains from the Red Buttes to Pike's Peak at least, a distance of more than four hundred miles. Sometimes some one of the divisions is concealed, for a short distance, by superficial material, but it reappears again under favorable circumstances. Between Cretaceous divisions No. 2 and the supposed Jurassic, or the Trassic, if the former is wanting, is a massive *bed of irregular*, fine grit, in many instances so silicious as to form a

fine quartzite. The upper part shows irregular laminæ of deposition. It is yellowish-white on exposure, with some masses of rusty rock. The lower part is a massive fine pudding-stone, composed of an aggregation of small, water-worn pebbles, apparently cemented together with iron. This bed, opposite Long's Peak, near Thompson's Creek, forms one main ridge and one sub-ridge. The sub-ridge comes about half-way up to the main ridge, forming a sort of break or notch; dip 17°. The main ridge has a dip of 19°, as observed from the summit. Then a very beautiful concave valley intervenes, about half a mile in width, to the next ridge, which is composed of gray limestone with brick-red beds. This is also composed of the ridges, forming really one main ridge. The first ridge has its southeastern slope covered with dark-blue limestone like a slate roof, with dip 24°. Beyond this dividing ridge we find the metamorphic rocks, so that everywhere the Carboniferous beds seem to rest directly on the metamorphic rocks, though not conforming. In almost all instances between the main ridges there is the bed of a stream sometimes dry, sometimes with water. Taken in the aggregate, these ridges, although inclining at so many different angles, at different localities, when not badly eroded or concealed by a superficial deposit, exhibit great system, convincing one at once that the upheaval was not a sudden paroxysm, but a long-continued, slow movement. These ridges are divided by little streams, which have cut their way through them, into separate parts, each portion 100 yards to half a mile in length. The harder layers usually protect the sides and summits of these ridges from too much erosion. Thence in a direct line from the metamorphic rocks to the level prairie southeastward cannot be over four miles. The lower or southern end of this ridge (for it runs out at Thompson's Creek), shows the red beds, and on the opposite side the rocks dipping in a contrary direction, forming one side of an anticlinal. The side next to the mountains dips 58°, and the pudding-stone stands up like a high wall for a mile or more in extent in its massiveness. This anticlinal curves around westward, so that the ends of the two sides meet at Thompson's Creek. At this creek there is a jog in the upheaval of at least ten miles; that is, north of Thompson's Creek the ridges die out, while immediately south, in the open prairie, the ridges commencing again far to the westward, and continually running out in the prairie southward, the line of fracture seeming to be northwest and southeast, while the trend of the aggregate range is nearly north and south, so that, passing along the foot-hills of the mountains from the south, northward, we see the ends of the ridges of upheaval, as it were, *en echelon*. These jogs are not uncommon all along the base of the mountain ranges. At Cache la Poudre there is one that is quite remarkable. Passing over the Cherokee trail from Thompson's Creek southward about six miles, we come to a ridge of sandstone near the road. Toward the mountains a terrace-like ridge is visible, which is composed of the yellow, chalky layers of No. 3. This sandstone ridge is No. 5, dip 13°, strike very nearly northwest and southeast. The black shale of No. 4 gradually passes up into the yellow and gray arenaceous sediments, in which are huge round concretions with foliated layers, and many shells of *Inoceramus*. This passes up into regular stratified sandstone, the layers varying in thickness from half an inch to a foot. This sandstone is mostly a rusty yellow, and moderately coarse-grained, and possesses nearly the same characters as No. 5, seen at the head of Teton River and Fox Ridge, on the Missouri. *Baculites ovatus* also occurs here in considerable numbers. The concretions are somewhat calcareous, as the shells indicate. Just before reaching St. Vrain's Fork the wall-like character of these beds is again seen. In the upheaval No. 1, sandstone is broken off, leaving a portion in a nearly horizontal po-

sition on the summit of a ridge 300 feet high, while the fallen part is near the base, inclining 65°. This wall extends for nearly a mile without interruption. I was informed that about three miles above this point, on St. Vrain's Fork, a man discovered a bed of coal while digging post holes. Further examination showed the seam of coal to be three feet thick, and that it had been used by a blacksmith in the vicinity, and pronounced by him as good as the bituminous coals of Iowa. This is quite possible, from the fact that isolated portions of the lignite formation may have been left after the erosive action which followed the elevation of the mountains. We know that the great thickness of Tertiary which we find eastward of the foot of the range, once extended in unbroken continuity across the area now occupied by the Laramie Mountains; and while it is impossible for a bed of coal to be discovered of very great extent, indications of it may be found even in the valleys, or on the sides of the mountains. Tertiary beds, with lignite, are found very near the summits of the Wind River Mountains, 12,000 feet above the sea. From Little Thompson's Creek, No. 5 approaches the foot of the mountains, and at St. Vrain's Fork the coal beds are near the mountains, or perhaps form a part of the foot-hills. It would seem as though the erosive power of water had not acted as strongly on the sedimentary rocks in this region, and, in consequence, Cretaceous beds form ridge-like walls against the sides of the mountains, which may have partially protected the Tertiary beds from being washed away. This is especially the case from St. Vrain's Fork to Boulder Creek, and doubtless beyond. Some of the tipped-up ridges of Carboniferous, Jurassic, and Cretaceous rocks are nearly 2,000 feet high, and incline 40° to 60°. Long's Peak is seen most distinctly from this point, though we are still forty miles distant. Near Left-Hand Creek there is a high conical hill, at least 800 feet above the bed of the creek, finely rounded, which is composed of lignite beds, which, as they were elevated and tipped away from the mountains, escaped erosion. The surface of this region for miles from the foot-hills of the mountains is covered with water-worn rocks of every variety, some of which are evidently of eruptive origin. The valley of Boulder Creek, with its border, is about six miles wide, and derives its name from the vast numbers of worn rocks which literally pave the whole surface. It is on South Boulder Creek, where the Marshall mines are located; and at this locality is the best exposure of all the rocks in this region. Just north of the cañon of the South Boulder is a nearly vertical wall of what appears to be basaltic or eruptive rocks rising at least 3,000 feet above the bed of the stream. On examining this closely, it would seem to be the Carboniferous beds, standing nearly vertical, presenting the most remarkable mural front I have ever seen along the mountains. The rocks are almost metamorphosed by heat, so that they are consolidated and hardened. Their dip is from 40° to 60°. Deep furrows are worn down the sides of this wall by atmospheric agencies, so that narrow vertical columns seem to stand out, adding to the wonderfully picturesque beauty of the view. At the foot of the highest ridge, myriads of massive, nearly square blocks have fallen down, gray with lichens. These blocks are a fine compact sandstone, siliceous, light gray, yellowish; no loose red material; stratification perfect. The red rock is hard and massive. Most of the rocks are brittle, when broken showing a vitreous fracture. The outside rocks seem to be less affected by heat, and would make the best kind of building material. Between the main ridge and the next succeeding, there is an interval of one-fourth of a mile. This valley-like interval is covered with grass and a few pine trees growing from a rich black soil. The next ridge is perhaps

1,500 feet above the bed of Boulder Creek, but only a few feet above the débris at the base, while the main ridge is at least 1,500 feet above this. This lower second ridge is a fine gray and yellowish-gray sandstone, with irregular laminæ, siliceous, of unknown age. One hundred yards farther is a third ridge, inclining at about the same angle, composed of pudding-stone, the same bed seen all along the margins of the mountains, from the Red Buttes to Pike's Peak, and supposed to be occupying the position of No. 1 Cretaceous. It certainly lies between well-marked Cretaceous and Jurassic beds on the North Platte. There is another interval grass-covered, and then the fourth low ridge, composed of shale, fine sand, and clay intermixed, inclining at an angle of 56°. Upon the surface of the thicker layer are numerous mud markings. The yellow arenaceous clay terminates quite abruptly, and a bed of gray, quite-hard limestone comes in. In this limestone I found in considerable numbers *Ostrea congesta*, and a large, rounded species of *Inoceramus*, referred to by Professor Hall in Frémont's report, but not named. Professor H. compares it with *I. involutus*, Sow. (Min. Con.,) but it is doubtless an undescribed species.* At any rate we can fix the position of this bed of limestone as No. 3. Between this point and the first opening for coal the distance is about two miles, and the intermediate rocks are concealed by a large deposit of drift material, but it is easy to see by the inclination of No. 3 that in this interval there is ample room for the existence of Nos. 4 and 5. I shall speak of the lignite beds, therefore, as Lower Tertiary until some more definite evidence is given to the contrary. I should have remarked that all these beds, even including the lower lignite beds, exhibit evidence of having been subjected to moderate but long-continued heat. These marks of heat decrease as we proceed outward from the nucleus of the range, but some of the layers of Carboniferous sandstone seemed to have been changed to a mica schist, the plates of mica being very distinct. No. 3 was quite changed, exhibiting a compactness, a hardness, and a fracture never before seen in any part of the West. The value of the coal in the lower bed, now worked by Mr. Marshall, has undoubtedly been greatly enhanced by the heat to which it has been subjected. Dr. Leconte observed similar phenomena, but on a much larger scale, in New Mexico and the Raton Mountains.

By the close proximity to the foot of the mountains, and the inclination of the strata, probably the most remarkable and complete section can be obtained that can be found anywhere. It seems hardly possible that so great a thickness of the Tertiary beds can occur, but the section taken at this point is the result of a pretty careful examination of one day under the immediate direction of Mr. Marshall, the owner of the mine, and the information he gave me is the result of over four years' experience at the mine. It is hardly possible that beds 6 to 13,† inclusive, have been broken down from some higher beds in the series. A more thorough examination at some future period will determine this. Beds 1 to 10, inclusive, incline 8° to the east; the remainder, 35° to 40°. Lignite beds 39 and 43 of the section have not been fairly opened yet, but were discovered in searching for iron ore. In clay bed 21 there are some features which cannot be well represented in the section. In addition to the main coal-bed are a couple of smaller seams. As the drift passes the upper seam becomes very hard, resembling anthracite, but it is so thin that no notice is taken of it by the miners. The following are the divisions of clay bed 22:

* Mr. Meek has since named it *I. deformis*, in Mr. King's report.

† See Report of Colorado and New Mexico, page 29.

7. Drab clay.
6. Lignite, 12 inches.
5. Drab clay, 6 to 12 inches.
4. Sandstone, 2½ feet.
3. Drab clay, 6 inches
2. Lignite, 1 foot.
1. Drab clay, 1 foot.

It is probable that the lowest bed of coal mentioned in the section will furnish the most desirable fuel. The day of my visit to these mines 73 tons were taken away, and Mr. Marshall informed me that an average of 50 tons a day were wrought. This coal brings readily $4 a ton at the mine, and from $12 to $16 at Denver, twenty-two miles distant. The coal has very nearly the hardness of anthracite, which it very much resembles, but it falls in pieces more readily. It can be exposed in a dry atmosphere without much injury, but water causes it to crumble in pieces at once. I spent two evenings at Mr. Marshall's, burning this coal in an open grate, and I found that with a moderate draught it burned with a clear, bright-red flame, produced a good amount of heat, gave off no offensive odor, leaving scarcely any ash, and no clinkers. It contains very little sulphur, and, indeed, no erosive elements. For all domestic purposes it will undoubtedly prove equal or superior to any bituminous coals, and, in a sanitary point of view, there is no comparison. I will here quote a few paragraphs from the report of Dr. John Torrey, United States assayer at New York, who analyzed specimens of coal for the Union Pacific Railroad from this place and Coal Creek, three miles south:

The mineral has nearly the hardness of ordinary anthracite, but is much more brittle. The fragments are often cuboidal or rhomboidal, and in some of them a little amber was detected. The luster was bright and shining. The coal does not stain the fingers. The powder is black when viewed in a heap, but when a thin film of it is spread upon a white surface it has a slight tint of brown. Specific gravity, 1.29. When heated in a glass tube, the temperature of which is gradually raised to 400° or 500° F., it gives off water, the last portions of which a little empyreumatic oil or tar. At a dull-red heat it takes fire, burning with a bright-yellow and smoking flame, emitting an odor between that of heated bituminous coal and that of imperfectly-burning wood. Some of the fragments gave out a slight odor of sulphur, which was traced to minute scales and spangles of iron pyrites, scattered here and there among the lumps. Compared, however, with most bituminous coals, this mineral fuel is remarkably free from sulphur. When submitted to analysis it yielded the following results:

Water in a state of combination, or probably its elements as in dry wood	20.00
Volatile matter, expelled at a red heat in the form of inflammable gases and vapors	19.30
Fixed carbon	58.70
Ash, consisting chiefly of oxide of iron, alumina, and a little silica	2.00
	100.00

The ash is mostly reddish, but sometimes light gray. Another specimen contained only 16 per cent. of water.

The coal from Boulder Creek, which occurs in a bed 4 feet thick, and in another 10 feet, has a general resemblance to that from the other locality. It is, however, more dense, having a specific gravity of 1.4, and is less brittle, and the fracture is not so glossy. It contains, also, flakes of mineral charcoal, scattered through the mass, and the proportions of its constituents differ considerably from those of the Coal Creek bed, it being a stronger fuel. It contains a little sulphur like the other; the composition is as follows, viz:

Water in a state of combination, or its elements	12.00
Volatile matter expelled at a red heat in the form of inflammable gases and vapors	26.00
Fixed carbon	59.20
Ash of a reddish color, sometimes gray	2.80
	100.00

From the characters and analyses of the specimens here described, it will be seen that the Rocky Mountain belongs to the class of lignites, and that it is not technically a bituminous coal, neither cannel nor an anthracite. Still, in common parlance, it will be regarded as coal. In calorific power the Rocky Mountain coal may be placed between dry wood and bituminous coal, and therefore it is a most valuable fuel, especially where bituminous coal and anthracite are not likely ever to be found, and firewood is difficult to procure. I see no other reason why it may not be used for the smelting of iron and other ores. For locomotives it could be employed to advantage, with some modification of the fireplace. The ash is so small in quantity, and so light, that most of it would be carried off by the blast of the furnace. From my own trials, I find that the coal burns freely in a small stove, making a hot and clear fire, and leaving no clinkers. The specimens that I have examined show a tendency to break up and crumble after they have been soaked with water and allowed to dry; so that it would be well to preserve the coal as much as possible from being wet by rain. The lumps that you brought home from your journey show no disposition to crumble in a dry place. In conclusion, I remark that the discovery of such extensive beds of a good mineral fuel is of the highest importance to the section of country in which they occur. The iron ore is limonite, commonly known by the name of brown hematite or brown iron ore. It is a compact variety, and is certainly derived from carbonate of iron, some of which, in an unaltered state, is evident in one of the specimens. The carbonate will probably be found in larger proportion as the beds are worked further in beyond the reach of atmospheric influence. There is reason to believe that the iron obtained from this ore will be of good quality.

The bed of coal opened on Coal Creek corresponded in every particular with the sixth bed, or bed 23, of the section on South Boulder, at Marshall's Mine. The drift was carried in about 150 feet. It was first opened in the summer of 1860, while Marshall's Mine was opened in the fall of 1858. The sandstone that lies above the coal seems to be in many instances nodular or concretionary, like that which occurs in a similar position on the Missouri River. This main bed of coal is 7 feet in thickness, and, with the beds above and below, inclines at an angle of 43° to the east. It is the great dip of the beds which renders these coal-beds far less desirable than those on South Boulder. Seven beds of coal have been opened on Coal Creek, and underneath the third bed is a layer of excellent fire clay, 6 or 7 feet thick. In this clay are found nodules of iron ore, containing impressions of leaves of deciduous trees. This nodular iron ore is abundant everywhere, however, in all the beds. Some of the nodules are filled with clay or sand. The coal has not been worked here for over two years, and, although only seven beds have been examined, there is no reason to suppose that the whole series will not be found on further examination. The distance from the Marshall's Mine, or South Boulder, to the Coal Creek opening, is just three miles; yet intervening, is a high plateau, 1,200 to 1,500 feet above the bed of the Boulder, extending close up to the foot of the mountains. Although this plateau is mostly composed of coal strata, yet it is covered with a vast thickness of drift material washed down from the mountains, so that the intervening formations are for the most part concealed. As in the South Boulder Valley, no Jurassic beds, and only traces of one or two Cretaceous can be seen in Coal Creek Valley. Even where it emerges from the mountains the drift material juts up against the almost vertical sandstones of the Carboniferous period, yet we cannot doubt from what we have already seen that the complete series of rocks exist underneath. All along the foot of the mountains in this region, in the valleys and on the hills, there is a wonderful accumulation of particles of worn, and even angular rocks, so abundant as greatly to impede traveling. They present also every variety of texture and composition; but what most strikes the attention is the partially metamorphic condition of many of these immense masses of the pudding-stone, which are found so abundant in the Carboniferous rocks, lying scattered about; the inclosed pebbles appearing not to have been affected by heat, while the matrix is almost changed.

There are also worn masses of gneiss, quartz, and most of the varieties of rocks that probably exist in the heart of the mountains. In the lignite beds on South Boulder are indications of spontaneous combustion, by which the rocks also have been baked. In all the coal-beds are quantities of wood, and in sinking shafts stumps are brought out which show the woody structure very perfectly. In the beds are masses of wood which are partially changed, the surface of which is composed of beautiful, jet-like coal, while the inner portions show the layers of growth. One of the beds is called the "peacock vein," on account of the iridescent hue of the coal, and this peculiarity seems to be confined to this bed. Before leaving this locality I will say a few words in regard to the iron ore which is found quite abundantly in the sand and clay beds inclosing the coal. The iron ore is, as Dr. Torrey has determined, a limonite, commonly known as brown hematite, or brown iron ore. It occurs in nodular masses, varying from an ounce to a ton or more in weight, and is never found in layers or strata, but is distributed through the beds. On breaking these nodular masses, we find regular concentric layers, looking much like the bands of an agate, oftentimes varying in color from brown to yellow. From the immediate vicinity of South Boulder Creek Mr. Marshall has already taken out more than 500 tons of the ore, and from the examinations which have been made it must occur in great abundance over an area of at least fifty square miles. I am convinced that for all practical purposes there is no limit to the supply of this ore. The experiments of Mr. Marshall, in the furnaces at this locality, show that 4,400 pounds of ore will produce one ton of pig-iron in about the following proportions: ore, 200 pounds; limestone, 20; charcoal, 13 to 15.

This produces a very excellent quality of gray iron. Although on Boulder Creek the coal-beds seem to be most largely developed and to present the greatest facilities for their study, yet there are openings in many other points of the Territory, at Golden City, and various localities farther down on Coal Creek and Boulder Creek. I was unable to visit any of these points, but I saw some of the coal which had been obtained from there. It is used more or less for fuel at all the little towns in this region, but I do not think it is as good as that from the Marshall's mine. That which I saw came from a mine opened along the stage route, low down on Coal Creek, and it had a dull-brown color and crumbled readily on exposure. Mr. Collier, editor of the Mining Register, gave me a list of exposures of coal in various parts of the Territory, and there is no doubt this list might be greatly extended. Twenty miles east of Cañon City coal occurs in bars or seams, also seven miles south of the same place. At Colorado City small seams are seen and it is taken out in bars. This is a very curious form and must have existed originally in the form of asphaltum, for it is now found in bars half an inch thick, two inches wide, and sometimes several feet in length. On Cherry Creek divide, twelve miles east of Denver and two miles above the stage road on Coal Creek, there is a 7-foot bed which Mr. Collier opened in 1860; two miles below this point another bed has been opened. There are here five distinct beds. Again, on Running Creek, twenty miles southeast of Denver, and on Bijoux Creek, sixty miles southeast of Denver, also on White River, western end of the Colorado. There is an excellent bed of coal, 7 feet thick, at Golden City, and three miles north of the city. Seven miles south of Golden City, in Bald Mountain, the jet is found. Seventeen miles up the Platte River from Denver, a bed 2 feet thick exists. It is said also to be found in the Middle Park. Leaving Boulder Creek I prepared to

return to Cheyenne City, along the main stage road, which is usually distant four to fifteen miles from the foot-hills of the mountains. Near a little town called Valmont, on North Boulder Creek, there is the most remarkable trap dike I have seen in the Territory. It rises about 200 feet above the little village at its base, and trends nearly east and west. It is about a mile in length and seems to have been thrust up through the Tertiary beds with vertical sides, so that it looks like a wall. The base of the dike is so covered with débris that it is not possible now to see what effect it had on the rocks through which it protruded itself. The rock might be called a hornblendic trachyte of a dark, greenish-brown color, the crystals of hornblende appearing quite distinctly. In the valleys of Boulder and St. Vrain's Creeks are a number of little lakes, many of them alkaline. The settlements are quite numerous and farming and stock-raising seem to be carried on extensively. It is only in the valleys of the streams, where irrigation can be employed, that any crops can be raised. The grass is so nutritious here that sheep and cattle thrive well and seem to be healthy. About four miles east of the base of the mountains the ridges of yellowish-gray sandstone are seen, dipping at a slight angle. They may be traced to a point within twenty miles of Pole Creek, and are plainly Tertiary. Near Thompson's Creek the most conspicuous feature in the scene is a high wall of sandstone with a hole through it, which has received from the old trappers of the country the name of the Bears' Church. Mr. Carbutt took a most excellent photographic view of it. The Cretaceous beds here form a belt about five miles wide. Eighteen miles south of Cheyenne City. No. 5 is well developed, inclining at an angle varying from 10° to 15°, and containing in some hard concretionary masses, a species of *Inoceramus*. Reposing on No. 5, without any apparent break in the continuity, are the Lignite-Tertiary beds. The following section will show the order of the beds here, as they are exposed over a considerable area:

7. Arenaceous clay with an abundance of *Ostrea subtrigonalis?*
6. Coal, 5 feet.
5. Clay.
4. Reddish rusty sandstone in thin layers.
3. Drab, arenaceous, indurated clay.
2. Massive yellow sandstone.
1. No. 5, Cretaceous, and arenaceous clay, a yellow sandstone.

The bed of coal is 5 feet 4 inches thick, 200 feet from the entrance of the drift. In the bed above the lignite there seems to have been a layer which must have been 3 or 4 feet in thickness. The oyster-shells are scattered about in the greatest abundance, reminding one in their abundance, size, and form, of the small oyster along the shores of South Carolina and Florida. It is said that among the foot-hills of the mountains outcroppings of the coal have been found. These irregular seams of jet, before referred to, occur abundantly in this region. I shall dwell more fully on these western lignites in my chapter devoted to that subject.

CHAPTER IX.

SKETCH OF THE GEOLOGICAL FORMATIONS ALONG THE ROUTE OF THE UNION PACIFIC RAILWAY, EASTERN DIVISION.

The facilities for traveling afforded me by the kindness of Colonel Lamborn, secretary of the Kansas Pacific Railway, induced me to make a hasty examination of the geology along this route so far as the road had been completed. Accordingly I left Leavenworth City November 13, 1867, and proceeded directly to the valley of Kansas River by way of Lawrence. This valley is one of the most fertile in the West, quite broad, the banks sloping gently down, presenting, however, a good many exposures. All the rocks from the Missouri River to a point near Fort Riley undoubtedly belong to the age of the Upper Coal-Measures, and, as these rocks have been described very fully in a paper by Mr. Meek and the writer, published in 1859, I shall not dwell on them in this connection. Even at Fort Riley the upper beds, over the summit of the hills, indicate their Permian character, and must be included in the series called Permo-Carboniferous. From Manhattan to Fort Riley the outcropping beds of limestone are quite conspicuous on the sides of the high hills, showing also a considerable thickness of the intervening clay or sand beds which form the grassy slopes. The bed that furnishes the beautiful building-stone at Manhattan, Fort Riley, and Ogden, and which has been used for the construction of some of the finest houses in Kansas, shows a marked dip to the westward at least 10 feet to the mile. The rock can be wrought into any shape with great ease, and is most beautiful and durable. At Junction City the Permian magnesian limestone is so soft that it is cut into any desirable form with a circular saw, and is transported to all points along the line of the railroad. Masses, in the form of bricks for chimneys, caps, sills, &c., are made in the greatest abundance. Junction City, which is a city of 1,200 to 1,500 inhabitants, is almost entirely constructed of this Permian limestone. At the one hundred and forty-fifth mile-post west of the Missouri the bed of limestone from which so much building material is taken crops out quite conspicuously from the sides of the hills, about 30 feet above the river, but dipping so rapidly that it soon passes beneath the bed of the river. After passing the one hundred and fifty-fifth mile-post, the soft beds, of those intermediate between the well-known Cretaceous No. 1 and the Permian, begin to show their influence on the surface of the country, giving very broad level bottoms to the river, and the low, gently-sloping hills on either side. Very few exposures of the basis rocks are to be seen.

Near Salina the grass-covered, sloping hills, the entire absence of any rock exposures, and the wide, level bottoms, show that the underlying rocks are composed of soft, yielding sands and clays. We know these belong to the series intermediate between the Permian and the rusty sandstones of the Dakota Group, and, so far as we have yet determined, are of doubtful age. At Fort Ellsworth the cuts along the road show that the Dakota sandstones have appeared, and then continue on as far as Fort Harker and beyond. Everywhere we find a thick, superficial covering of arenaceous material which was evidently derived from the disintegration of No. 1. Our road was along the valley of the Smoky Hill Fork, and the bluffs in the distance look as though they were composed of loose sand. It is plain that as we pass southward the sandy beds below the red sandstone, as seen on the Little Blue River, increase *in thickness and retain* their variegated color. The soil is still good all

along the road. Where the surface crust is cut through by the road we observe from one to three feet of vegetable soil. It is somewhat arenaceous and would be very favorable to the production of cereals and all kinds of garden vegetables, but there must be more or less irrigation. There is no timber here except a little fringe along the Smoky Hill Fork and some of its branches, and this is being fast removed as fuel for the use of the road. The surface is very rolling, showing the loosely aggregated character of the underlying basis rocks. The prairie grasses grow thickly over the ground, especially the short buffalo grass, which forms a mat in most places. No finer grazing country can be found in the world. At Wilson's Station I saw the chalky limestone of the Niobrara Group filled with *Inoceramus problematicus*. A part of the bed is in slabs or thinnish layers, as it usually appears wherever it occurs south of the Missouri River, but a part also is more massive, arenaceous, and rust-colored. Between the two hundred and forty-fifth and two hundred and fiftieth mile-stone west, the road cuts through No. 3 very distinctly, the whole country appearing to be underlaid by this rock. The superficial deposits are quite heavy in places, composed of a deep yellow or flesh-colored marl, with small white concretions of lime or chalk. This disintegrated material seems to take the place of the newer pliocene deposits on the Loup Fork and other places. Between the two hundred and fiftieth and two hundred and fifty-fifth mile-post we saw a small herd of buffalo within a short distance of the track, also a herd of forty or fifty antelope. As the locomotive moved along they seemed more like native cattle grazing over these limitless pasture fields. We saw the mirage which is not uncommon in this country. Even small ridges rose up into lofty mountains and every valley reflected the light, so that it appeared like a pond of water. At the two hundred and eightieth mile-post there seemed to be indications of Tertiary beds, and in the cuttings are thousands of the small white limestone nodules so common in the marls in other localities. I made inquiry at the station, but no rock has yet been found in that vicinity. The bluffs along the creek have a whitish appearance. At Hays City the massive rocky layers of No. 3 are sawed into blocks with a common cross-cut saw, and employed in the construction of buildings. It is a rather hard chalk, but is very easily worked, the shells, as *Inoceramus*, *Ostrea congesta*, &c., obstructing the saw to some extent. The builders informed me that this rock hardens after it is laid in the wall. The quarry from which this chalky limestone is obtained is about four miles from the village, and the bed is 40 feet thick. Fort Hays is located on Big Creek, a branch of Smoky Hill Fork. It is surrounded by a broad, rolling prairie country, and no timber in sight except the very narrow, irregular fringe of cottonwood along the streams. The soil appears to be fertile; indeed, it could not be otherwise with the basis rock composed of the limestones of No. 3, but the difficulty of irrigating will prevent the country from being used otherwise than as a grazing region, for which purpose it seems eminently suitable. The short nutritious grasses which are peculiar to this dry prairie region cover the surface like a mat, and it is not strange that the buffalo are so fond of this portion of the West, and still visit it every summer. About eight miles west of Hays City there are about 60 feet exposed, of the dark clays of No. 2, of the Fort Benton Group. The road cuts through it so as to show its character well. It is a bright bluish-black slaty clay, covered with a thin coating of iron rust whenever the water or air can have access to it. It is full of arenaceous concretions of every size, which are lined inside with crystals of calc-spar. On the summit of the hills, *resting direct on No. 2*, are the massive layers of the yellow

chalk No. 3, containing a few oysters and a huge *Inoceramus*. On the Smoky Fork are exposures of the bluish clays, with thin layers of arenaceous limestone containing fossils. At Fort Wallace the buildings are all made of this whitish chalk. This rock is also used in the construction of bridges along the road in many places, and, although not a durable stone, seems to serve a good purpose. We have, therefore, between Salina and Fort Wallace, exposures of three divisions of the Cretaceous, Nos. 1, 2, and 3. In No. 1 are found in great abundance well-preserved impressions of dicotyledonous leaves, as magnolia, oak, sassafras, poplar, sycamore, willow, fig, walnut, &c. There are also various casts of shells of unknown species. In No. 2, not far from Fort Wallace, have been found, the remains of gigantic reptiles 40 or 50 feet in length. No. 3 contains an abundance of the usual species, *I. problematicus* and *O. congesta*, with fragments of fishes. The interval between Wallace and Denver has not yet been examined by a competent geologist, and, therefore, nothing definite is known in regard to its geology. This chapter contains such observations only as I was able to make during a brief trip along the line of the railroad.

In regard to the resources of Kansas, I cannot do better than to close this chapter with an extract from a memoir prepared by Mr. Meek and the writer from observations made in the summer of 1858, and published in the Proceedings of the Academy of Natural Sciences at Philadelphia:

"Although this paper is merely designed to give a brief sketch of the leading geological features of those portions of Northeastern Kansas visited by us, we cannot close it without alluding to the truly great agricultural and other natural resources of this new and interesting territory. We mean no disparagement to other portions of the Mississippi Valley when we state that after having traveled extensively in the great West, and after having seen many of its most favored spots, we have met with no country combining more attractive features than Kansas Territory. Her geographical position gives her a comparatively mild and genial climate, intermediate between the extremes of heat and cold, while the rich virgin soil of her beautiful prairies is admirably adapted to the growth of all the great staple grain and root crops of the West. It is true that in some districts there is rather a deficiency of timber, but as a general thing there is along the streams sufficient for the immediate wants of the country. In addition to this, the wonderful rapidity with which forests are known to have sprung up on similar prairie lands in Missouri, as the country became settled so as to keep out the annual fires, shows that the present scarcity of timber should not be regarded as presenting any serious obstacle to the settlement of the most extensive prairie districts in Kansas. Before going out into the interior of the Territory we had expected to find the whole country immediately west of Fort Riley comparatively sterile; on the contrary, however, we were agreeably disappointed at meeting with scarcely any indications of decreasing fertility as far as our travels extended, which was about 60 miles west of Fort Riley. Here we found the prairies clothed with a luxuriant growth of grass, and literally alive with vast herds of buffalo that were seen quietly grazing as far as the eye could reach in every direction.

"Even on the high divide between the Smoky Hill and Arkansas Rivers, south of this, we found the soil rich and supporting a dense growth of grass; and from all we could learn from persons who have gone further out, the same kind of country extends for a long distance beyond this toward the west. Hence we infer that the belt of unproductive lands between the rich country on the east and the eastern base of the Rocky

Mountains on the west is much narrower than is generally supposed; and even this so-called desert country is known to possess a good soil, which may be rendered fruitful by artificial irrigation.

"In regard to the mineral resources of Kansas we have at present only time and space to say a few words: As already stated, coal is known to exist, though its extent is not yet fully determined, at several localities in the region of Leavenworth City, while the geological structure of the country, as well as discoveries already made, warrant the conclusion that this important and useful mineral abounds at many localities south of there. Limestone suitable for building purposes and the production of quicklime exists throughout large areas, while inexhaustible beds of gypsum are known to occur at several places not far west of the mouth of Solomon's River. Near this place we likewise saw in the lower cretaceous rocks crowning the summits of the Smoky Hills deposits of iron ore, but were unable to determine, in the limited time at our command, whether or not it exists in large quantities. Of the discoveries of gold in the mountains on the western border of Kansas much has been said; nothing, however, but a thorough geological survey, by authority of the State government, can lay before the public such full, accurate, and reliable information on these subjects as will bring from the older States the capital, skill, and enterprise necessary to develop the great natural resources of the country."

CHAPTER X.

THE EXISTENCE OF BEDS OF PEAT IN NEBRASKA.

The subject of peat is also of the highest importance to the West, and one which deserves much more attention than it has yet received. While the dry climate of Nebraska would necessarily prevent the accumulation of vast deposits of this useful fuel, such as we know to occur in many portions of Europe and on the Atlantic coast, yet even if beds of two feet or more in thickness can be found of peat that can be used as a fuel, it will prove a discovery of inestimable value to the State. Peat is usually regarded as holding a position next to coal in its value as a fuel, but of course its real value will depend upon the amount of carbon it contains. Low, marshy, swampy places occur all over the State, and, so far as I could determine, in a somewhat hasty examination, the conditions indicated were favorable to the existence of valuable beds of this fuel in almost every county. It is my opinion that at no distant day peat will become an article of great pecuniary value in the West, and that large fortunes will be made in its preparation from lands which are now regarded of little value. The first step to be taken is to ascertain the elements of success; and the proper way to answer the question whether there are actually any peat-beds in the State, and whether they can be wrought with profit, is to proceed at once to some neighboring State where the working of peat-beds is in successful operation, and determine the character of the peat and the mode of its preparation. Much discredit is often thrown upon new enterprises on account of the want of knowledge and experience on the part of the persons concerned, and the subsequent almost certain failure is attributed to other causes. It has already been shown by Dr. White, the State geologist of Iowa, that peat exists in great quantities in that State, and it is even now wrought with profit by companies which have

been organized for that purpose. This subject is regarded of so much importance to the people of Iowa that it is receiving a large share of the attention of the State geologist. In Minnesota, also, there are said to be vast deposits of peat, so that the supply is almost unlimited. Now if these statements are true, if we had no other knowledge, we should at once infer that peat beds of greater or less size and value must occur in Nebraska and the neighboring Territories. The conditions, as well as the character of the vegetation, must be nearly the same in all these States. Peat, so far as the West is concerned, may be defined as the slow decomposition of flags, rushes, and the common sedges and grasses under water a portion or all of the year. But very little accurate information in regard to this matter is known in the West. Many people who have read much about the peat-bogs of Ireland suppose that in order that there should be peat deposits there must be a vast growth of mosses. The great dryness of the climate prevents the growth of mosses to any extent in the West, and very few species occur there. Still in many of the Eastern States this subject is exciting much attention, and enormous prices are sometimes paid for peat-bogs. Some expensive machinery has also been invented for its manufacture into fuel. At Pittsfield, Massachusetts, there is a company that manufactures 100 tons of crude peat per day, which, when dried, is reduced to 30 tons. In New York State a peat bog was purchased at the rate of $400 per acre, and a gentleman in New Jersey refused $25,000 for 28 acres. Now, if the reader will refer back to the special reports on the different counties he will observe that there is scarcely a county in the State which has not more or less of those low bogs, in which there is a rank growth of reed grass and bulrushes, which are the resort of myriads of muskrats. In most of the true peat-bogs the conical huts of the muskrat may be seen. Now, where these masses of vegetable matter are covered with water so that they do not have access to the air for the greater part or all of the year, a process of slow decay or combustion goes on by which this vegetable matter is converted into peat. There are no large beds of mosses as we so often see east of the Mississippi, and even in the region of the Rocky Mountains this family of plants is very meagerly represented. In Ireland, Scotland, and some other portions of Europe, there are beds of peat or turf 20 to 40 feet in depth. The heather grows in the greatest luxuriance, and especially the sphagnum, which has a wonderful avidity for moisture and remains fresh all summer. These mosses decay at the roots while the tops keep fresh and green, so that these peat-bogs increase in depth from year to year. In our Western as well as Eastern States there are certain kinds of aquatic plants that contribute largely to the vegetable matter in a bog. In all the marshy bottoms or low-lands of the West we find, oftentimes in great abundance, the water *Polygonums*, the pond lilies *(Nymphæa* and *Nuphar)*, duck-weeds *(Lemna)*, pickerel-weed, *(Pontederia)*, arrow-weed *(Sagittaria)*, pond-weed *(Potamogeton)*. Many of these plants grow in deep water, with stems several feet in length, and with such luxuriance as to contribute yearly a large amount of vegetable matter to the bog. There are many kinds of peat which may be readily detected by the experienced eye. These differences are sometimes in color, some kinds being red, others gray, others black; sometimes they are almost entirely destitute of fiber or any traces of vegetation; again they are light and porous, and do not seem to be far advanced in the stage of decomposition. Some kinds of peat are so pure that, burning, only a small per cent. of ash remains. Others contain much soil, lime, iron, and other mineral substances.

The geological formations of the country seem also to determine the character of the vegetation which forms the peat. The surface rocks of Nebraska are mostly calcareous, and the vegetation of the low places is composed of the coarse grasses and sedges. In granitic and silicious districts, according to Professor Johnson, the peat-bogs are likely to be filled with mosses.

Peat as an article of fuel.—Perhaps it is hardly necessary, at this time, to enumerate, in detail, the multiplied uses of peat as an article of fuel, and yet the want of information on the subject has been felt by the writer, even in his more recent investigations. He has made use of all the writings within his reach, but for the facts contained in this chapter he is mostly indebted to a thoroughly-scientific work by Professor S. W. Johnson, "Peat and its Uses," and an interesting volume by T. H. Leavitt, "Facts about Peat." To these books, which are readily accessible to any one, the reader is referred for any further information. Mr. Leavitt has invented a machine which will work off 100 tons of crude peat, making 25 tons or more of condensed fuel, per day. The crude peat is dumped into a hopper, wet, as it comes from the ground, completely pulverized, so as to destroy its porousness, and worked into molds like bricks. When we consider that there is, in all probability, hundreds of acres of peat ground in Nebraska that would, with this machine, yield from 100 to 500 tons of condensed peat per acre, worth at least $10 per ton for fuel, we can at once conclude that the subject is well worthy of our earnest attention. This prepared peat seems to be a favorite fuel for all domestic purposes. It is commonly cut or molded into blocks or sods like bricks, with a length of 8 to 18 inches, a breadth of 4 to 6 inches, and a thickness of 1½ to 3 inches. There are other forms made, sometimes in circular masses or in balls. Mr. Rogers, of England, found by experience that peat was prepared by the drying process, in the month of March, by the strong winds, rather than in the hotter months of June, July, and August. So when there was little or no wind he created an artificial wind for that purpose by placing the sods in wicker frames and swinging them through the air, thus drying the sods in less than half the time. When thus prepared it is used in the heating of dwellings, by means of a furnace, stove, or open grate, and is said to give a more steadily-intense and mellow heat than any other kind of fuel. It is also used in manufacturing establishments in the production of iron, and the fact that it is free from sulphur makes it a favorite fuel for that purpose. It has been used also very successfully for generating steam. Experiments are said to have been made on the locomotives of the New York Central Railroad, where a half ton of peat performed the work of one ton of coal. Another experiment was tried on a steamboat on the Hudson River, when 1,200 pounds of peat lasted two hours and twenty minutes, while 1,200 pounds of coal were used in one hour. In France turf-peat is a favorite fuel for the manufacture of iron. At one of the shops 4,500 pounds of turf and 2,300 pounds of pig-iron produced one ton of puddled iron; 26 cubic feet of turf and 2,500 pounds of pig-iron yielded 2,000 pounds of bar-iron of superior quality. In Bavaria, also, 3,000 pounds of dense turf to 2,450 pounds of puddled iron produces a ton of small bars of fine quality.

Peat charcoal and turf charcoal are much used, and their freedom from sulphur and acids renders them very useful. In Holland the manufacture of brick, alum-works, breweries, bakeries, are all carried on with turf as fuel. Mr. Rogers, at the request of the Emperor of France, made experiments on the Paris and Orleans Railway, and he found that the quantity of steam produced by peat was three times greater than that

of coal coke, while the steam was got up in one-half the time. The blaze was so great as to pass out of the furnace of the engine. The use of peat as fuel is almost universal in European countries; and east of the Mississippi the attention has been turned in that direction within a few years. It is found on examination to be widely distributed, and it is probable that it will be found to a greater or less extent in every State and Territory of the United States. The area covered with peat will, of course, depend much on the geological formation and the climate. We cannot look for such unlimited deposits in the West as in the East. The climate of the West is too dry, and there is comparatively little wet or boggy land, and an extensive swamp is hardly known. It is estimated that there are 120,000,000 tons in Massachusetts, which at the low price of $1 per ton would yield the enormous revenue of $120,000,000. In the State of Virginia several companies have been organized to work the peat-beds of that State; and it has been ascertained that the great Dismal Swamp, which had heretofore been regarded as waste land, is one of the most valuable deposits of peat in America. The Dismal Swamp Peat Company has already commenced operations with marked success. In a report from the latter company the following paragraph occurs, which at once reveals the interest connected with these great deposits:

> The peat of the Dismal Swamp has been the growth of uncounted ages. Recent geological investigations have established the fact that 'The Bare Garden,' which is the richest and best portion of this enormous peat field, was once covered by a gigantic forest of resinous woods, principally the gum-tree, cypress, juniper, and pitch-pine, which flourished in primeval luxuriance. When these forests were prostrated by convulsions, or the slow process of decay, they were decomposed and covered with mosses and grasses which accumulated for many centuries until, by gradual chemical changes, peat, extending to undiscovered depths and richer in caloric ingredients than almost any other peat hitherto discovered. Analyses of specimens by the ablest chemists in this country have fully attested its value. And its future influence on this country will be surpassed only by the great coal deposits.

If the few words written on this subject aid in awakening an interest in this matter throughout the West, the object will be attained.

CHAPTER XI.

ARTIFICIAL BUILDING MATERIALS.

The importance of ascertaining what kind of building material can be used, not only in the State of Nebraska, but in a large portion of the West, which can be manufactured without the use of fuel, cannot be overestimated. In this chapter I have gathered such facts bearing on this point as seemed to me to be of value to the people of the West, and to them I would call their earnest attention. I am convinced that if a company could be formed which would enter into the business of making pressed brick, pisè, patent concrete, or any excellent building material which could be afforded cheap to the settlers of these almost treeless plains, it would confer a very great benefit on the inhabitants, and secure a large pecuniary return. The absence of fuel either above or beneath the surface of so large a portion of the West will be my excuse for the suggestions which I shall make in this chapter, whether any of them are ever adopted or not.

1. In regard to pisè, (pronounced peè-za,) a French term given to a method of building which has been long in use on account of its cheap-

ness and economy in many of the departments of France, and has always commended itself on account of its neatness, strength, and durability, and as the earthy materials for such buildings are very abundant all over the State, and indeed in every part of the West, I will here give a brief statement of the method of preparation, referring the reader to Rees' Cyclopedia, under the article Pisè, for the details and illustrations. The walls of the building to be erected are formed by means of a mold made of boards, which are placed on their sides so as to inclose a space equal to the desired thickness, and then the earthy materials are placed in this mold in a damp condition, and rammed into a compact mass by a rammer of a peculiar kind, when it is left to dry. This rammer should be wedge-shaped, and made of the hardest kind of wood. Any small lumps of earth are thus crushed and the materials are well mixed, while the surplus water in the earth is pressed out, and the particles of earth are more closely united. Hence these houses or walls are constructed with great rapidity, and are remarkable for their healthiness, cheapness, strength, and durability. It is said that these walls may be made at the rate of three courses of three feet each in length in a day, and that as soon as the walls are high enough to receive the roof the heaviest rafters can be placed upon them without danger. The next question that arises is, where shall the farmer look for the earthy materials he needs for his purposes, and are they abundant in the State? The materials are all around him in unlimited quantities. In Rees' Cyclopedia we have the kinds of earth given which are suitable for this purpose: 1st, all earths in general are fit for such use when they have not the lightness of poor lands, nor the stiffness of clay; 2d, all earths fit for vegetation; 3d, brick earths; but these, if they are used alone, are apt to crack, owing to the quantity of moisture which they contain. This, however, does not hinder persons who understand the business from using them to good advantage. 4th, strong earths, with a mixture of small gravel, which for that reason cannot serve for making either bricks, tiles, or pottery. These gravelly earths are very useful, producing the best work of this sort. Any one who is familiar with those vast superficial deposits of sand and gravel which cover all of Western Nebraska and the greater portion of the treeless surface of Colorado, Montana, and Dakota, know how abundant the best of materials are for this kind of work. There are also certain marks by which the commonest observer may determine whether the right kind of materials are in his vicinity. When a spade or plow brings up lumps of earth; when arable land lies in lumps; when field mice are able to make subterranean passages; when roads or streams form ruts or channels in the ground and the sides remain firm, but especially are these materials found in great abundance at the foot of the hills where vines are planted, and all sloping cultivated lands. The presence of lime greatly improves the quality. It therefore follows that the yellow marl which attains such a great thickness all over the eastern portion of Nebraska, must be especially valuable for this purpose. In case the exact kind of earth is not found at the place where it is necessary to build, it is important to learn how to mix the earth so as to render it suitable. Strong earths must be tempered with light; when clay predominates there must be a mixture of chalk or lime and sand, and the proportions in which this mixture is made must be determined by the judgment of the builder. It is better to mix some small pebbles, gravel, rubbish, indeed any small mineral substances, but nothing of an animal or vegetable nature. These harder substances bind the earth firmly, and being pressed, and pressing in all directions, renders

the whole more firm and solid, so that at the end of two years the wall becomes as hard as freestone, and a chisel must be used to break it, like any solid rock. This material can also be used for the building of walls, as the inclosures for parks and gardens, for fences, for fields, &c. The ancients used it for making rough walls; the Italians now use it for the construction of terraces that cover their houses; the Moors for all their walls; the Spaniards, French, and others, for some of the floors of their apartments. The strength and durability of these houses, built in this way, is shown from the fact that some of them have been pulled down, the title-deeds of which, in the possession of the proprietors, showed them to be one hundred and sixty-five years old, and they had been kept in poor repair. The rich traders of Lyons have no other way of building their country houses. These buildings, by painting in fresco, may be made to look as beautiful as the owner may desire by the use of red or yellow ocher, or any other mineral paint. Along the Rhine many of the beautiful mansions which gladden the eye of the traveler as he glides along its banks, are made of nothing but these earths. In the dry climate of the West these houses could be inhabited almost as soon as finished. Besides the great strength and cheapness of this method of building, it has the advantage of speed in its execution. One may calculate to a day the time when a certain work can be completed. It is known that two men can build in one day six feet square of the Pisè; then six men, which is the number required (three in the mold, and three to dig and prepare the earth), will build in sixteen days, or at the end of three weeks, at least 228 square feet of wall, or a solid and lasting habitation sufficient for the necessities of a family. Six men can complete a wall 540 feet long and 6 feet high in one month, and twelve men can finish the same work in fifteen days. Thus, by multiplying the number of molds and workmen, the rapidity of construction will be proportionately increased. The building is floored, roofed, and finished within like a stone or brick house, except that lathing on the walls is not necessary. The above facts are given merely to show the simplicity of this process of building, and its admirable adaptability to the wants of the western people.

Patent concrete.—Although Ransom's patent concrete, which is so popular in England, may never be brought into general use in this country under that name, yet the principle involved must be adopted to a greater or less extent; and as it seems to be so valuable, even to the production of a better and stronger building material than can usually be found in a natural state, I will here notice a few of its prominent features. It seems to me very proper that some of the methods of making artificial stones be briefly described in this connection, in order that the attention of builders may be called to it and some advantage be taken of the vast supply of materials that cover the country. The materials which are used in forming the "patent concrete" are mostly sand, which may be molded into any form. Even rubbish, fragments of rock, and almost any kind of loose sandy material, may be employed, and there is scarcely a county in the State that has not an abundant supply. The rock is made with great rapidity, and is ready for use without drying or burning. It hardly requires a temporary shed in this dry climate, for its manipulation is not affected by the weather. The rock becomes, when made with sand and cemented with the silicate of lime, a true sandstone. It is made by saturating the blocks in a solution of the silicate of soda and then applying a solution of the chloride of calcium. This produces a rapid double decomposition, leaving an insoluble silicate of lime within the stone, and a soluble chloride

of sodium (or common salt,) which could afterward be removed by washing. A coating of hard silicate of lime has actually formed and deposited on the surface. Mr. Ransom made small blocks of various forms in the presence of a committee appointed for the purpose of examining the merits of this invention, mixed coarse sand with the fluid silicate of soda, and then dipping the mold into the chloride of calcium, there came out almost instantly a compact, solid, and evidently durable material. In such solids there appears to be no element of destruction. Many experiments were tried to ascertain the strength of this material, and it was found that very few of the natural rocks could compete with it. It was compared with the celebrated Portland and Caen stone, and found that a bar of the concrete stone 4 inches square and 8 inches between the supports sustained 2,122 pounds, while the Portland and Caen broke respectively at 750 and 780 pounds. It was also shown that the adhesion of the concrete by suspension was 1,980 pounds, while the others separated at 1,104 and 768 pounds. The lectures of Professor Ansted, of England, on the various kinds of economical rocks are of great interest, and he particularly commends this concrete as one of the cheapest, most beautiful, and durable of our artificial building materials.

In connection with this subject I would call the attention of the western people to the American Building-Block Company, the office of which is at No. 24 Vesey street, New York. The principle involved is very similar to the one already described. The merits of this invention may be best explained by the following extracts from a pamphlet published by the company:

A good, durable material for the construction of buildings, that combines facility of manufacture, cheapness, beauty of color and shape, convenience in handling, resistance against changes of atmosphere, and complete fitness for the uses for which it is intended, has been a want so well understood, that much time, capital, and labor have been devoted to its attainment.

The building-blocks manufactured by this company are believed to fully and completely meet all the above requirements.

These blocks are easily and rapidly made, each machine being capable of turning out about five thousand per day, and three or four machines may be run by one steam engine of thirty-horse power.

They are composed of the cheapest known materials—mainly sand and lime—and are made in such form and size that walls can be constructed from them as cheaply as with good common brick.

In their external appearance these blocks make a building of unsurpassed beauty. The shape is entirely uniform, with sharp, well-defined lines, and they can be made of every variety of shade, from a pure white to a dark-brown stone color.

These blocks, as now manufactured, are ten inches long, five inches wide, and four inches thick, containing two hundred cubic inches, and weighing about eleven pounds each; they have an air-chamber running through the center, which facilitates the handling of them, both in transportation and in their construction into buildings.

The fact that air is one of the best non-conductors, and a wall built with these blocks having air-chambers running vertically through the entire wall, shows conclusively that changes of temperature will be less felt in houses constructed from them than in those built of any other material.

The blocks, from the nature of the material used, and the severe pressure to which they are subjected in process of manufacture, are very durable in their character, as it is a well-known and established fact that mortar composition, properly made, is the most enduring of all substances, withstanding exposure for centuries, and constantly growing harder by atmospheric changes, until it becomes a perfect stone.

These blocks have been subjected to every conceivable test—have been immersed in water until they have absorbed all the moisture which they could hold, and in that condition have been exposed to severe frosts and then thawed, and the same process repeated again and again. After being subjected to all the alterations of the atmosphere, the result in all cases has but proved the *indestructibility of the block.* And it is believed to possess all the enduring qualities of the old Roman mortars, which have existed unchanged for over three thousand years, except to become harder and harder.

Blocks identical in *shape* and *size,* but not in hardness, known as the Foster block,

and composed of much the same materials as those manufactured by this company, have, fortunately for the actual test of their durability, been made, and houses built from them ten or eleven years ago. These houses are stronger and better to-day than when first erected. The material would long since have been in general use, but for the difficulties and obstacles which have now, happily, been overcome by means of devices and improvements which are covered by several letters-patent owned by this company. The block, as before stated, is mainly composed of lime and sand, and is molded under immense pressure; but in addition to the pressure, the blocks, as formerly made, required time to become sufficiently hard to be fit for use; this was an objection. The machines used to mold them were presses made in various ways, not one of which proved strong enough to do the work for any profitable length of time. This was a very serious obstacle. And the fact of the blocks being insufficiently solidified by pressure, and the want of experience and knowledge in the manipulation and after-treatment of the materials forming the blocks, caused some of them to be made of an inferior quality, which did the composition injustice, and has retarded their general introduction,

The first of these difficulties has been overcome by improvements in the composition and mode of treating the mixture before and after pressure.

The second has been overcome by the invention of a machine so constructed as to produce all the density attainable.

The theory of this composition, relative to its strength and durability, is simple and easily understood, and has been fully demonstrated to be practically and chemically true.

Clean, sharp sand, when brought in contact with caustic lime in correct proportions, and under right conditions, with proper manipulation and after-treatment, produces a partial decomposition of the sand, by which silicate of lime is generated—*an indispensable condition and an invariable result.* In this condition the composition is ready for the mold and the press. The block thus formed, when exposed to the air, gradually parts with a portion of its moisture, and begins to absorb carbonic acid from the air, for which the lime has an affinity. This process goes on slowly; a portion of the water present, and that afterward absorbed, being chemically taken up and combined in the form of crystallization. This process goes on until the interstices of the stone are filled up, and the block becomes non-absorbant, growing harder for years, by the action and effect of the very agents that destroy freestone, marble, brick, &c., viz, water, frost, and carbonic acid from the atmosphere.

The novel form of this block, having an air-chamber running vertically through the center of each block, six inches long by one inch wide, is so arranged as to secure a circulation of air through the entire wall, operating as a perfect non-conductor of moisture, cold and heat, making a perfectly dry wall inside, a cool house in summer, and a warm one in winter.

This perforation likewise facilitates the seasoning or hardening of the block evenly and thoroughly, presenting more surface to the action of the elements that perfect the block. The size of the block above alluded to is considered, for general purposes, the most convenient, but the manufacturer is by no means confined to it; for it is contemplated to make all sizes, from that of the common brick to the ordinary-sized brown stone and marble fronts, plain or fancy, as it may be molded in any desired form, and is, therefore, adapted to all kinds of buildings, as churches, halls, factories, houses, stores, cottages, stables, barns, or any other class of buildings, including bridges, sewers, docks, water and drain pipe, lawn and garden ornaments, tiles, statuary, vaults, ornamental work, &c., combining, it is believed, more positive advantages than any other building material now in use.

While this block has heretofore been rather imperfectly made, it has stood the test of time and the elements. Ample evidence is at hand to prove to the entire satisfaction of the most skeptical the durability of the block. Buildings constructed ten years since from it have clearly demonstrated its indestructibility. The intelligent, practical mason, familiar with its component parts, admits it to be reliable; and those learned in the science of chemistry, pronounce it imperishable; and the only reason why this material has not been more generally introduced to the public for building purposes was for the want of proper machinery to manufacture the blocks.

Years of time and thousand of dollars have been expended in efforts to reach the point where we now stand. We are now prepared to offer to the public the results—a building material which possesses the following merits, many of which are peculiar to itself:

1. Its material composition is such that, so long as the laws of chemistry hold good, time will but make it more durable.

2. It is made in such form, and with such exactness of outline and dimensions, that walls built with it give complete protection against atmospheric changes, and are fireproof. Buildings can be finished cheaper and better than if of brick or wood. Interior walls may be left unplastered when desired, or, if plastering be preferred, it can be had at one-third of the cost, and of a better and more durable quality than by ordi-

nary modes, as a coat of hard-finish may be applied directly upon the face of the wall, for which it has a strong affinity, attaching itself so firmly that it cannot be scaled off, thus saving the expense of studding, furring, lathing, and two coats of plaster, and leaving no hiding place for vermin that so frequently find shelter in a lath-and-plastered wall. The saving of the item of plaster is estimated to be about seven-eighths over the quantity required in constructing a brick lath-and-plastered house. There is another advantage gained, which is, the certainty of having walls that will never crack in the plaster.

3. The affinity of mortar for the material—both being of the same nature—is such that the bond is much stronger than in the case with brick or stone. In this respect the superiority is so great that it must be seen to be fully realized, as a wall built from this material becomes, in fact, one compact mass of stone.

4. The sharpness of outline, the shape and size, the exactness of dimensions, (which are not warped or impaired by burning, after being molded,) and the color of the blocks, which can be modified or varied to suit the taste, all furnish the skillful architect with means for producing the most beautiful effects.

For the interior of churches and public buildings, designed to be finished in imitation of stone-work, it is most admirably adapted, either for columns, walls, or ceilings, especially if arched and groined, as it is not liable to discoloration or cracking, as is the case with lath and plaster. You get all the effects and durability of real stone at a small part of the cost, and the subdued color of the blocks gives a tone and quality most grateful to the eye.

5. The economy attainable by their use is not the least advantage. These blocks may be made wherever good sharp sand can be found, (the places where sand is not obtainable are rare,) in sections where there is neither stone nor clay for bricks, and in such districts the value of these inventions can hardly be overestimated.

The above statement being true, have we not that which will satisfy the great want that has been felt throughout the ages, from the time when men became wise enough to build houses rather than huts? Combining the great elements of durability, availability, the greatest possible protection from atmospheric changes, strength of walls as a whole and in all their parts, beauty in color and texture, in form and proportion, cheapness without a sacrifice of any requirement—what more can be desired?

Professor E. N. Horsford, of Cambridge, Massachusetts, one of the most eminent chemists and scientific experts in this country, made a most careful examination of the merits of the building block manufactured by this company.

Foster's patent is *new*. It differs from common sand and lime mortar in essential particulars. It is a STONE, while mortar is a material for binding stones together. The latter cannot be substituted for the former. Foster's stone owes its distinguishing characteristic to its having been produced under pressure. By means of this pressure and the small proportion of water employed, a product is obtained from common materials, suited to new and distinct uses, where uniform size and determined form are important—as in the erection of buildings—and in which great density and strength are required. By means of this pressure the sand grains are settled into positions of less mobility, and more surfaces have been brought into contact or close proximity. Within the stone there is developed silicate of lime, a cement, at the surface of each sand grain and binding it to its fellow. This cement is more effective because of the sand grains. The less the thickness of the layer of cement required the more effective it is. The hardness of Foster's stone is due in some degree to the formation of hydrate of lime, and double hydrate and carbonate of lime, as in common mortar, and to the formation of silicate of lime at the surface of the sand grains, but more to the pressure, which, by reducing the thickness, has increased the effectiveness of the cements. Common mortar, in setting or drying, becomes porous from the escape of surplus water. Through the pores thus left, the carbonic acid of the air enters and forms the double hydrate and carbonate; but, at the same time, prevents the formation of the more tenacious silicate of lime.

I have analyzed a series of samples of artificial building stone, made by Foster and others—one of them that had served eleven years as part of a foundation wall, and others of various lesser ages, some of them only a few days old. In the oldest of them only was the lime all combined and rendered substantially insoluble. This sample was nearly as hard as Connecticut River sandstone. Others of only a few months' age were equally hard at the surface, but less firm in the interior. The surface of a freshly-made block, exposed to the air, rapidly hardens, while the changes within are slower. A fresh fracture of a block several years old shows a zone of peculiar shade, extending from the outer surface toward the heart of the stone. This zone marks the progress of certain chemical changes which attend the hardening process, and illustrates the fact of the improvement of the stone *with age*. These changes are accompanied by increase *in weight, due to carbonic acid absorbed* from the air, and moisture absorbed

and combined with the steadily forming silicate of lime. I have found, by experiment and analysis, that a block of Foster's building stone, eleven years old, contains from ten to fourteen times as much silica combined with the lime in the process of manufacture, and after it was molded and pressed, as was contained in a fresh block made by the same process. This increased amount of silicate of lime, as well as of double hydrate and carbonate of lime, is in keeping, as already suggested, with the observed increased hardness of the stone as it grows older.

The newness of Foster's patent is in the process and in the proportions of the ingredients he employs, rather than in the character or kind of the ingredients themselves. Of these ingredients he makes a portable stone of definite form, having the same kind of advantage for building purposes that bricks have. The originality and validity of the patent seem to me beyond doubt.

Van Derburgh's invention is the application of heat to the mixture of sand and moist hydrate of lime, to increase the amount and effectiveness of the cement before the blocks are molded. The *amount* of cement is increased, inasmuch as the production of silicate of lime from a mixture of sand, lime, and moisture is facilitated by heat, as I have demonstrated by experiment, and this has been brought to bear for a length of time before the materials are molded and pressed. The effectiveness of the cement is increased, since the mode of manufacture spreads the cement more uniformly over the surface of the sand grains.

It has been found in practice that blocks made by Foster's process are subject to the condition of the atmosphere, whether moist or otherwise—that is to say, under the influence of a dry atmosphere, immediately after molding and pressing, they do not harden; whereas blocks made by Van Derburgh's process are not influenced by the hygrometric condition of the atmosphere, but the process of hardening goes steadily and uniformly forward. It is also found, in practice, that by first slaking the lime and then mixing it, as a powder, with moist sand, as in the process of Foster, the slaked lime does not so effectually and uniformly coat the sand as when the mixture is made with moist sand and finely-ground unslaked lime, and the whole subjected to heat during the process of slaking, as in the method of Van Derburgh. By slaking the lime in confined space, with, or by means of, the moisture at the surface of the sand grains, the nearness of the hydrate of lime formed to the silica, on which it is to act, is greater, and its chemical affinity is greater, both from the nearness and from the heat due to slaking, and to the admitted steam, than it can be where the hydrate is cold and dry, and encounters moisture at the surface of the sand grains. In the latter case the condition approximates to that of milk of lime and sand, in which, according to Fuchs and Petzholdt, little or no action takes place. In the former, chemical affinity between the silica and lime is aided, not only by the nearness and heat, but also by the nascent condition of the caustic lime, at the instant of its slaking, in contact with the sand. In Van Derburgh's process the ingredients enter the block in a more advanced stage of the chemical action that is to result in solidification; more freshly-formed silicate of lime exists in the block, when molded and pressed, under Van Derburgh's improved process than under the process of Foster. Microscopic examination shows the individual sand grains in a Van Derburgh block to be coated by a more transparent crystalline cement than is the case in Foster's block. This transparency and crystalline character are evidences of greater tenacity in the cement, because of the greater extent of surface and thickness through which the cement exerts its binding force. They are due in part to the hydrated silicate of lime, in part to the double hydrate and carbonate, and, doubtless also, in a fresh fracture, to the crystallized hydrate. This hydrate, on exposure to the atmosphere, absorbs carbonic acid, forming additional double hydrate and carbonate, which imparts greater tenacity and hardness to the extent of the action, and accounts, for the most part, for the rapid hardening which a fresh surface experiences on exposure to the atmosphere.

I have prepared samples of building blocks from Berkshire sand and chemically pure lime, as nearly as might be in the laboratory, according to the practical working of Van Derburgh's, and according to the patent of Foster. These blocks, upon analysis, gave the following results:

Silicic acid combined with lime, for every hundred parts of quicklime employed—

In Van Derburgh's	5.02
In Foster's	2.76

I have also analyzed a block of Van Derburgh's stone, some twenty months old, and find the proportion of silica derived from the sand of the block, by the action of the lime at the time the block was made, and during the period that has since elapsed, to be very large. Assuming the composition of the block to be nine of sand to one of quicklime, I find the proportion of silica, produced by the action of the lime, to be 49.67 for every hundred of lime. This percentage, compared with the silica of a block of Van Derburgh's stone freshly prepared, using chemically pure lime, gives a ratio of *0.7430, 0.0751*, or nearly 10 to 1. Compared with the silica in a block of commercial

quicklime, it gives a ratio of about 42 to 1; while Foster's block, eleven years old, gives a ratio in the best specimen of 13.5 to 1.

I have found, by experiment, that a fresh block, made by Foster's process, placed in an atmosphere made artificially dry, does not harden so rapidly, or so thoroughly, as in ordinary atmospheric air, and especially as in moist atmospheric air. I have also found that, in an atmosphere highly charged with carbonic acid, the hardening of the block does not seem to be promoted, if the atmosphere be dry. These results might have been inferred from the general principle that the chemical action of the lime on silica, as well as the absorption of carbonic acid, and its combination with lime, demand moisture. They confirm the results of experience with the Foster building blocks, before mentioned, and enable one to see why a block in which more silicate of lime is formed at the outset, as in Van Derburgh's, should be less dependent, for its hardness, on the hygrometric condition of the atmosphere.

I regard the practical working under the Van Derburgh patents, as now carried out, as based upon a new and distinct invention, producing results decidedly superior to those formerly obtained by the process of Foster.

I have given an opinion to Mr. Strout, of Portland, on the claims of Foster, Van Derburgh, Ransome, Ruschhaupt, and other patentees, in which my attention had been drawn to only three out of seven of Van Derburgh's patents bearing on the subject. From the language of the patents submitted to me, I did not gain a just conception of Van Derburgh's processes, as practically carried out, and objected to them on account of the apparently great time required, and the moderate production to be expected. I have become satisfied from actual inspection of the process of manufacture that this great time is, in practical working, unnecessary, and that the whole operation is very simple, and permits continuous and rapid mixing, molding, and pressing.

The claims of Van Derburgh, Ransome, and Ruschhaupt, to some extent, cover common ground.

Van Derburgh may justly claim:

1st. The slaking of the lime in contact with the moist sand, which is to be made into building blocks, and, after subsequent dampening, subjecting the mixture to pressure to form building blocks.

2d. The application of heat to a mixture of lime, in the process of slaking, and moist sand, the heat being derived from the slaking lime, or from this and other sources combined, preparatory to pressing into blocks.

3d. The slaking of the lime in contact with the moist sand in confined space, by which very great heat is brought to the aid of the chemical action of the caustic lime on the silica of the sand.

4th. The subjection to pressure of a mixture of moist sand and lime, slaked in contact with the sand of the mixture, after having been subjected to heat.

5th. The use of a mixture of lime, slaked or unslaked, with sand, with the addition of a liquid silicate immediately before molding and pressing.

6th. The saturation, with a solution of an alkaline silicate, of blocks made by pressing a mixture of moist sand and caustic lime.

7th. The use of saccharate of lime and soluble silicates in the formation of silicate of lime in building blocks.

8th. The use of freshly-broken sand grains, to fill interstices between coarser grains, and thus produce a smoother and harder artificial stone.

9th. The application of pressure, by percussion, to a mixture of sand and lime, in whatever form his patents cover.

That the manufacture of artificial building materials without the use of fuel will be an object of zealous pursuit is an absolute necessity. The various earths for that purpose are distributed all over the country in the greatest abundance, and the peculiar dryness of the atmosphere renders the climate especially adapted to success in that direction. The above extracts have been made in this chapter for the purposes of conveying information to the people of the West on this most important subject, and we propose to pursue it much farther in future reports.

PART II.

PALEONTOLOGY.

BY

F. B. MEEK.

H. Ex. 19——6

NOTE.—When this report was prepared, it was understood by the writer that it would be published in royal octavo size, and the accompanying plates were arranged accordingly. It was subsequently decided, however, by the authorities, that the regular edition would have to be printed on the smaller standard-sized octavo paper used for public documents; consequently it was found that the edges of the plates would either have to be folded, or that they would have to be in some way reduced in size. As they could not well be rearranged so as to remedy the difficulty, it was finally determined to have a photograph of each plate made one-eighth diameter less than originally prepared, so that the lithographer could make his tracings of outlines and details from these reduced photographs, and then finish the shading of the same directly from the original drawings: which task has been well executed by Mr. Sinclair. This brings the plates to the required size, and at the same time diminishes the individual figures so slightly that those originally drawn of natural size are, in scarcely any case, less than the smaller sized adult individuals of the species, while those that were at first drawn larger than natural size, are only a little less magnified in the lithographs. In order to prevent any misapprehensions in regard to the sizes of the fossils, however, careful measurements are in all cases given in the text in connection with the description of each species.

F. B. M.

REPORT ON THE PALEONTOLOGY OF EASTERN NEBRASKA,

WITH

SOME REMARKS ON THE CARBONIFEROUS ROCKS OF THAT DISTRICT.

BY F. B. MEEK.*

INTRODUCTORY REMARKS.

There are probably few well-informed geologists who will, at the present time, maintain that the occurrence of a very similar, or even the same group of fossils, at widely separated localities, necessarily proves the rocks in which they are found to be of exactly contemporaneous origin. The most that is now generally maintained in this regard is, that such identity or correspondence of types at very distantly separated parts of the world, indicates that the strata in which they are embedded were formed during the prevalence of identical or similar physical conditions at some time during the same great geological epoch, and that they hold the same, or nearly the same, *relative* position in the geological column of their respective districts. For instance, although a stratum in the Rocky Mountains, containing the remains of very nearly the same fauna as some particular subdivision of the Devonian system of Europe, might, for aught we know, be hundreds of years older or newer than that particular division, we would have little or no room for doubting that it belonged to the great Devonian series, or possibly even to some definite known horizon in that series. We could moreover very positively assert, in such a case, that it would be, according to all past experience, useless to seek there at any lower geological horizon for workable beds of coal, or to expect to find Silurian rocks or any of their peculiar products above, supposing there had been no overturning of the strata at the particular localities.

Hence, although paleontology does not enable us to ascertain the exact *actual* ages of rocks—when applied with due caution and skill in connection with a careful observance of their stratigraphical arrangement and lithological and other physical characters—it does afford the means of fixing their *relative* ages, as well as of identifying the same beds at different localities, within given fields of observation, with very considerable precision. It is therefore not merely *one* of the more important aids to the geologist in his investigations, but in the present state of geological science, it is the only sure guide in classifying and determining the order of succession of rocks, where this cannot be done by their actual continuity or obvious superposition. For these reasons, it is now the universal practice, in all geological surveys conducted upon sound scientific principles, to devote especial attention to this department.

In the present instance, this becomes the more particularly desirable

* I am under obligations to Professor Henry for all desired facilities while preparing this report, at the Smithsonian Institution.

in order to throw as much light as possible upon questions of both scientific and economical bearing, since rather widely different views are entertained by geologists in regard to the age and position in the geological column, of some of the rocks in Eastern Nebraska, with relation to the Coal-Measures and other Carboniferous deposits of this country and Europe.

This discordance of opinion has caused the writer to enter into more minuteness of detail in giving local sections, and repeated lists of fossils found in each particular bed and seam of rock seen at different localities, than would otherwise have been done. To all geologists familiar with our western Coal-Measures and their characteristic organic remains, it may also seem superfluous to bring forward arguments to prove that no part of the rocks under consideration can either belong to the Lower Carboniferous, or to the Permian. My apology for discussing at length a question already so clear to all in this country acquainted with the subject, is the fact that an eminent foreign geologist (Professor Geinitz, of Dresden) for whom I have great respect, from an examination of an incomplete series of specimens from these rocks (and doubtless partly from not being acquainted with the range of species and genera in the Carboniferous system of this country) has referred the outcrops here described along the Missouri in part to the Lower Carboniferous, and in part to the Permian. As his views on these points have probably been accepted, at least by some geologists in the Old World, it has been thought desirable to place before the reader all the facts now known that have a bearing on the questions at issue.

In order, therefore, to afford a fixed standard of comparison between the organic remains of the Nebraska deposits under consideration, and those of well-established horizons in the Coal-Measures of Iowa, Missouri, Illinois, Kentucky, &c., I have considered it proper to give figures and descriptions of as many of the species of these Nebraska fossils as possible. With this view, eleven plates of closely arranged figures have been prepared, illustrating a few more than one hundred species, belonging to the several groups, *Foraminifera*, Corals, *Polyzoa*, *Brachiopoda*, *Lamellibranchiata*, Trilobites, &c., together with a few fishes, all of which are more or less fully described in the following text.*

Although most of the species are known to range through the entire series, the figures of those from the several outcrops that have been referred by others to widely different horizons are arranged on different plates, in order to illustrate, as far as it can be conveniently done, the vertical range of the various types. To do this completely, however, would require the repetition of most of the figures on each of the plates from specimens obtained at Bellevue, Plattsmouth, Rock Bluff, and Nebraska City. But as the Omaha, Bellevue, Plattsmouth and Rock Bluff outcrops so obviously all belong to one unbroken series of Upper Coal-Measures,† and are even all acknowledged by Professor Geinitz, after a study of their organic remains, to be Carboniferous, the figures of their fossils given are here arranged together on Plates 1, 2, and 3; though the particular locality and position of each is mentioned in the text in

* These fishes have been described in a separate section by Professor O. St. John, of the Iowa and Illinois geological surveys, who has devoted several years to the study of that branch of paleontology with Professor Agassiz, at Cambridge.

† It may be proper to explain here, that by the use of the terms Upper, Middle, and Lower Coal-Measures, we simply mean the upper, middle, and lower parts of the true Coal-Measures, and not any divisions that are separated by constant paleontological or physical breaks in the series. We have no Coal-Measures below the horizon of the Mountain limestone of the Mississippi Valley, such as are sometimes, in other countries, *called Lower Coal-Measures.*

connection with the descriptions, and further illustrated in the accompanying sections. For convenience, this division of the series might be provisionally designated as the Platte division, from its development in the vicinity of the mouth of Platte River, where the various outcrops seem to exhibit altogether a thickness of between two and three hundred feet. It should be borne in mind, however, that there is no paleontological or constant lithological break between these beds and beds A and B, at Nebraska City, Wyoming, &c.; while bed B is closely related by most of its organic remains with the bed C above, at the first-mentioned locality.

The fossils figured on Plate IV, with the exception of a few noted in the explanations as being from outcrops on the Missouri below Nebraska City, at Brownville, Aspinwall and Rulo, believed to hold entirely, or in part, a position above the horizon of division C at Nebraska City, were all found (at various depths) in a shaft sunk nearly one hundred feet, on Hon. J. Sterling Morton's place, one mile and three-quarters west of the Nebraska City landing, commencing at an elevation of 73 feet above low-water mark of the Missouri. In regard to the exact relations of the beds penetrated by this shaft, to the outcrop at the Nebraska City landing, there is some room for doubts. If Professor Marcou was right in referring the beds exposed at Mr. Morton's place, at the top of the shaft, to the lower part of the section seen at the landing, then the beds passed through by the shaft must hold a position immediately below the base of the section at the landing, and between the latter and the horizon of Rock Bluff section; but if the outcrop at the top of shaft really holds a higher stratigraphical position than any part of the section at the landing, as there are some reasons (to be mentioned in another place) for believing, then the fossils figured on Plate IV, as the species would indicate, may belong in part to the horizon of division C, and in part to division B, of the section at the landing. This question, however, being involved in some doubt, it has been thought the better plan to figure the species from the shaft on a plate by themselves, distinct from those obtained at the Nebraska City outcrop; and this plate is placed provisionally between those containing the forms from bed B, and the plates including the fossils from the still lower Platte division.

The species found in division B, at Nebraska City, Bennett's Mill, and Wyoming, are arranged together on Plates V and VI; while all the known forms from bed C are arranged on Plates VII, VIII, IX, X, and XI. As we did not succeed in finding good specimens of all the numerous species known to occur in division C at Nebraska City, and it seemed highly desirable that they should all be here fully illustrated together, a few of Professor Geinitz's figures of species from this horizon have been copied, and in each instance duly acknowledged in the accompanying explanations.

Of all the species figured and described, comparatively few are entirely new to science, though many of them have not before been illustrated by figures; while the excellent illustrations of many of the others published by Professor Geinitz, in his recently issued work on the fossils of these rocks (Carbonformation und Dyas in Nebraska, 1866), are accessible to comparatively few in this country.

As Professor Geinitz has referred a number of these Nebraska fossils to European species, from which they seem to me to be entirely distinct, figures of the European species to which he referred them are also given on the same plates, for comparison. These have been copied with great care, from the *most reliable figures* accessible, and in most cases from

those originally published by the authors of the species, in order to give the student the means of forming his own conclusions in regard to the relations of the American forms to the foreign species.

Having enjoyed an opportunity, during the spring of 1867, in connection with the Nebraska geological survey, to examine personally, not only in Nebraska, but through rather wide areas in Iowa, and portions of Kansas, numerous natural sections, quarries, shafts, drifts, borings, &c., in the rocks from which the fossils described in this report were collected, some of the facts observed may be appropriately stated here, before entering upon the paleontological descriptions.

Although thin beds of these Upper Coal-Measure limestones are known to exist under the bases of the hills bounding the Missouri Valley, a little above the surface of the river, for eight or ten miles above Omaha City, the quarry just below that place was the highest northern point at which these rocks were examined during the late survey. The base of these quarries is almost on a level with high-water mark of the Missouri, and the whole thickness exposed is only about eight feet, consisting of hard grayish and bluish gray, rather impure limestones, in four to ten inch layers, with more or less flinty concretions, and arenaceous clay partings, all showing a slight local east or northeast dip. The fossils found in these layers were *Fusulina cylindrica*, *Scaphiocrinus (?) hemisphæricus*, *Archæocidaris triserratus*, *Productus costatus*, *P. semireticulatus*, *P. longispinus*, *P. Prattenianus*, *Spiriferina Kentuckensis*, *Athyris subtilita*, *Spirifer cameratus*, and teeth of *Peripristis semicircularis*.*

We were informed by one of the workmen at the quarry that a thin bed of black shale occurs beneath the limestone of the quarry, but it was not exposed at any place examined. The limestone is said to make good lime, and is well adapted to most kinds of masonry, while in hardness and strength, and the thickness of the layers, it is found to be an excellent material for door and window caps and sills. Unfortunately, however, the heavy deposits of Drift and Loess overlying these rocks, add materially to the expense of working the quarries. The superincumbent Drift is at some places from 10 to 40 feet in thickness, resting directly upon the hard, upper layer of limestone. It consists of arenaceous clays and sand, with at places oblique planes of deposition, and contains some pebbles and a few boulders. Above the Drift the Loess rises back with the slope from a few feet to perhaps 150 feet.

As noticed by Professor Egleston in his report of geological examinations made along the first hundred miles of the Pacific Railroad, as well as by Dr. White, in a paper published in the American Journal of Science, the upper bed of limestone at the above-mentioned quarries shows very distinct glacial scratches. The upper layer was not sufficiently uncovered at the time of my visit to show very clearly the direction of the striæ, but Professor Egleston mentions seeing them at some places with a direction south 8° east. Dr. White also saw them at other places ranging south 41° west by the magnetic needle, the variation of the compass being here about 11° east of north. From all the facts observed in this region, it is quite probable that a considerable thickness of Upper Coal-Measure strata, consisting of some beds of hard limestone, has been here ground off and swept away by glacial agencies, leaving the upper surface of the remaining limestones planed off, and sometimes beautifully striated or even polished.

As an indication of the nature of the rocks below the horizon of the

* The only tooth of this fish found at this locality was discovered by Dr. White, the *State geologist of* Iowa, who accompanied the writer while examining these quarries.

quarry at Omaha City, the following statement of the beds perforated in a boring made at that place to a depth of four hundred feet, by the Union Pacific Railroad Company, is added:

*Statement of a boring made in the Missouri Valley at Omaha City, by the Union Pacific Railroad Company, starting 22 feet above low-water mark of the Missouri.**

No.	Nature of strata penetrated.	Depth.
		Feet.
1	Black soil (alluvial)	20
2	Sand and lime rock. [Doubtless the rock quarried below the city]	10
3	Slate mixed with coal. [The black shale under the quarry rock]	5
4	Fire-clay	8
5	Lime-rock	16
6	Fire-clay	3
7	Shale and lime rock	5
8	Green-sandy slate	7
9	Sand-rock with soft seams	11
10	Lime-rock	29
11	Magnesian [?] limestone	5
12	Coal slate. [Bituminous shale]	6
13	Sand and lime rock	10
14	Slate	4
15	Lime-rock with soft seams	17
16	Red slate with hard layers. [Red shale and indurated clays]	31
17	Sand-rock	4
18	Lime-rock	3
19	Blue slate	40
20	Lime-rock	24
21	Soap-stone with hard layers lime-rock 15 inches thick. [Alternations of limestone and indurated clay]	28
22	Coal slate. [Bituminous shale]	7
23	Fire-clay	4
24	Lime-rock	35

*I am under obligations to General Dodge, the chief engineer of the Union Pacific Railroad, for the foregoing memorandum *of the beds passed through by this* boring.

No.	Nature of strata penetrated.	Depth.
		Feet.
25	Soap-stone. [Indurated clay]	5
26	Lime and sand rock with seams of flint	8
27	Black slate	3
28	Gray soap-stone. [Indurated clay]	13
29	Yellow soap-stone. [Indurated clay]	20
30	Lime-rock	2
31		18
	Total	401

In this section the names by which the several beds were designated by the parties who kept the memorandum of the same, are in all cases retained, as I had no opportunity to examine the borings. I have, however, added in brackets a few suggestions, as it is evident some of them, such for instance as "soap-stone," "gray soap-stone," "yellow soap stone," &c., are not applied as generally understood in geology. It is also quite probable that there may be some errors in the details of the different seams and beds passed through, as it would be very difficult for any person not versed in lithology to be always strictly right in regard to the true nature and composition of rocks perforated in this way, by merely examining the borings brought up by the auger. The nature of the rock penetrated by the lowest 18 feet was not given in the section copied, and I failed to get any information in regard to it.

As we know nothing respecting the organic remains contained in these rocks, of course we cannot positively demonstrate that they belong to the same general series of Upper Coal-Measures as the beds exposed at the quarry just below the city, but it must be evident enough to any one familiar with the lithological characters of our western Carboniferous rocks, that they certainly correspond to no part of that system holding a position below the horizon of the Millstone grit, while they do agree quite well, in their general features, with portions of the Upper Coal-Measures of Iowa, Kansas, and Nebraska, as well as of Northern Missouri.

The most important fact revealed by this boring is that no workable beds of coal exist beneath the horizon of the Missouri Valley there within 400 feet of the surface. This, however, is not surprising, as all the investigations of these rocks in Western Iowa, Northern Missouri, Kansas and Nebraska, tend to the conclusion, as will be seen further on, that there is a considerable thickness of Upper Coal-Measure strata in that region, nearly or quite barren of workable beds of coal. As this is a question, however, in which not only the stockholders of the Pacific Railroad, but the whole community of this region are interested, it is to be hoped that this boring will be continued on deep enough to decide, positively forever, whether or not deep mining here can be expected to supply in quantity a good quality of fuel.

The first locality south of Omaha City, at which I had an opportunity

to examine an exposure of these Upper Coal-Measure strata satisfactorily, was at Bellevue, 10 miles south of Omaha, where the following succession of beds was observed.

Section of beds exposed at Bellevue, with an enumeration of the fossils found in each.

No.	Nature of the beds, with the fossils found in each.	Thickness.
		Ft. In.
11	Heavy deposits of Loess, underlaid by Drift	200 0
10	Hard, dark-gray silicious limestone	2 0
9	Bluish and drab clays	6 0
8	Hard, dark silicious limestone. *Productus longispinus* (?), *P. Nebrascensis*, *Aviculopecten occidentalis*, *Myalina subquadrata*, *Fusulina cylindrica*, *Spirifer planoconvexus*, *Phillipsia major*, and *Peripristis semicircularis*.	2 0
7	Dark shale, with a 2-inch seam of good coal, showing together about 15 inches. *Spirifer planoconvexus*, *&c.* Unexposed space, about 5 feet.	6 3
6	Gray and yellowish argillo-calcareous bed, splitting into thin pieces where exposed.	2 6
5	Light clay above and dark laminated shale below	2 6
4	Light-gray and greenish clays	2 5
3	Soft yellowish, slightly gritty layer, passing into harder impure limestone.	2 6
2	Very hard massive gray and bluish-gray impure limestone, with *Fusulina* and traces of embedded oolitic particles.	3 0
1	Yellowish, light-gray, and hard brittle whitish limestones, with some argillaceous layers, all below high-water mark of the Missouri. *Fusulina cylindrica*, *Fistulipora sp.*, *Archæocidaris*, *Erisocrinus typus*, *Fenestella sp.*, *Hemipronites crassus*, *Chonetes granulifera*, *Productus punctatus*, *P. Nebrascensis*, *P. symmetricus*, *P. costatus*, *P. semireticulatus*, *P. longispinus* (?) *P. Prattenanus*, *Rhynchonella Osagensis*, *Athyris subtilita*, *Spirifer lineatus*, (=*S. perplexus*, *McC.*,) *Sp. cameratus*, *Spiriferina Kentuckensis*, *Terebratula bovidens*, *Myalina subquadrata*, *Pleurotomaria spharulata*, *Macrocheilus inhabilis*, *Allorisma subcuneata*, &c.	18 0
	Total thickness of Carboniferous beds	47 +

At the time of our visit to this locality the Missouri was so high as to cover all of the lowest member of the section, but in 1853 Dr. Hayden and I had a fine opportunity to examine it when the water was low, while waiting there for a steamboat, on our return from an expedition to the Bad-lands. These lower beds were at that time best exposed directly above the old landing. The beds above No. 1 of the section are seen at various places along the shore and base of the hill for about a quarter of a mile above the landing.

The whitish, hard, brittle layers of the lower member of the above section, make beautiful white lime, while some of the other beds afford good building-stones. Excavations have been made at places under the bed No. 8 in search of coal, in the dark shale No. 7, in which there is a thin seam of *coal from one to two inches* in thickness. This coal is of

good quality, but is of course useless, in consequence of the thinness of the seam. At another place a little farther up the river, an excavation or short drift was made in search of coal, under No. 10 of the foregoing section, in the clays No. 9, but no indications of coal were observed, though a very fine spring of clear, cool water was developed.

It is worthy of note in this connection that the rocks forming the foregoing section, as well as those mentioned at Omaha, were referred by Professor Marcou (see Bull. Geol. Soc. France, 2d ser., vol. xxi, p. 132) to the Mountain limestone series. Any one, however, having the slightest knowledge of the fossils of our Carboniferous series will at once see from those mentioned in the section, as well as from those found at Omaha, that these beds belong to the true Coal-Measures. Some of the species, it is true—such as *Productus semireticulatus*, *P. costatus*, *P. punctatus*, *Hemipronites crassus*, &c.*—are known to be common to our Coal-Measures and the Lower Carboniferous rocks, but all the others mentioned are peculiar to the Coal-Measures, not one of them, so far as known to the writer, having ever been found in the West below the horizon of the Millstone grit. It will also be observed further on, that all of these same species, with perhaps some two or three exceptions, occur together, along with other Coal-Measure forms, in the very beds referred by Professor Marcou to the Permian or Dyas south of the Platte, and the few exceptions alluded to, such as *Macrocheilus inhabilis*, and *Pleurotomaria sphærulata*, are well known Coal-Measure forms.

On the north side of Platte River outcrops of Upper Coal-Measure rocks, that had been previously noticed by Dr. Hayden and Professor Egleston, were examined at several places along the bluffs from three to four miles up from the mouth of that stream. The particular localities examined are about five miles in a southwest direction from the exposures mentioned at Bellevue. These beds are said to rise considerably higher somewhat farther up the Platte than at the localities here alluded to, where the northeastward dip of a few degrees brings them lower. The exposures examined present the following succession of beds:

Section of the beds exposed on the north side of Platte River, between three and four miles from its mouth, with an enumeration of the fossils found in each bed.

No.	Composition of the beds.	Thickness.
		Ft. In.
12	Drift and Loess	150 0
11	Hard, massive, light-grayish limestone, composed mainly of oolitic particles, and *Fusulina* embedded in a compact calcareous base. *Syringopora multattenuata, Productus costatus, P. Nebrascensis, Myalina subquadrata.*	3 0
10	Light-grayish clay	6 0

*Professor Marcou also mentions among his collections from these rocks, *Productus pustulosus, P. scabriculus, Athyris plano-sulcata and A. Royissii*, but the first two are almost beyond doubt, only *P. symmetricus*, and *P. Nebrascensis*, as they appear in the condition of casts, when broken from hard limestone. At any rate, Professor Geinitz identifies them also in the so-called Dyas at Plattsmouth. The *A. plano-sulcata* is the same Coal-Measure form described by McChesney under the name *A. orbicularis*, and the other sp. (*A. Royissii*) was not identified by Professor Geinitz among the Bellevue collections.

No.	Composition of the beds.	Thickness.
		Ft. In.
9	**Hard, yellowish** limestone, with some flinty concretions, and toward the upper part, soft decomposing isolated masses, from a few inches to 1 or 2 feet in diameter. *Productus Prattenianus, Athyrus subtilita, &c.*	2 6
8	**Whitish,** hard, brittle limestone, in layers 5 to 8 inches thick, with light-colored clay partings. *Fusulina cylindrica, Axophyllum sp., Scaphiocrinus (?) hemisphæricus, Archæocidaris triserratus, Synocladia biserialis, Productus longispinus, P. costatus, P. Nebrascensis, Chonetes Verneuiliana, Spirifer cameratus, Spiriferina Kentuckensis, Athyris subtilita, &c.*	6 0
7	Light drab or grayish indurated marly clay. *Rhombopora lepidodendroides, Axophyllum sp., Fusulina cylindrica, Scaphiocrinus (?) hemisphæricus, Lophophyllum proliferum, Synocladia biserialis, Hemipronites crassus, Orthis carbonaria, Chonetes granulifera, C. Verneuiliana, Productus semireticulatus, P. costatus, P. longispinus, P. punctatus, Rhynchonella Osagensis, Spirifer cameratus, S. lineatus, Spiriferina Kentuckensis, Athyris subtilita, Terebratula bovidens, Chænomya, Myalina subquadrata, &c.*	4 0
6	*a.* Hard, dark-gray compact limestone ..... 8 inches.. *b.* Light-gray indurated marlite ..... 24 do.... *c.* Black shale ..... 4 do.... *d.* Light-gray indurated marlite ..... 14 do.... *e.* Hard, dark impure limestone ..... 6 do....	4 8
5	Light-grayish, slightly gritty, soft marlite	2 6
4	Bluish indurated crumbling clay or marlite, stained reddish purple.....	3 0
3	Bluish ash-colored (sometimes stained purple above) soft argillo-calcareous rock, becoming harder and in thicker layers below, with partings and irregular layers of soft yellowish marly clay, containing numerous *Chonetes granulifera, Rhombopora sp., Synocladia biserialis, Productus symmetricus, P. Nebrascensis, Hemipronites crassus, Athyris subtilita, Spiriferina Kentuckensis, Fusulina, &c.*	7 6
2	Black laminated shale	6
1	Very hard, bluish, compact argillaceous limestone.....	1 0
	Thickness of Carboniferous beds.....	40 8

The base of this section was estimated to be about 20 feet above the valley of Platte River, and about 23 feet above high-water mark of the Missouri. All the beds show a dip of 2° or 3°, in a direction to the east of north. They were observed to rise quite perceptibly in tracing the outcrops a little south of westward, up the Platte; though there is probably a reverse of dip farther up.

In these rocks, here as elsewhere, the different subordinate beds are sometimes liable to change materially their lithological characters and thickness within comparatively short distances, as can be occasionally clearly seen in following an uninterrupted outcrop a mile or so. For instance, the bed of clay, No. 10 of the above section, which is 6 feet in thickness at the particular place where the upper beds of this section were observed best developed, is reduced to a mere seam of an inch or two in thickness, or in places entirely wanting, so as to cause the bed 11 to rest directly down upon No. 9, at other localities within less than a mile further eastward.

It will be observed that nearly all of the fossils mentioned in the Bellevue section also occur here, along with a number of other well-known Coal-Measure species. It is also evident that the lower member of the Bellevue section is represented by Nos. 8 and 9 of this section, and No. 2 of the former by No. 11 of the latter, the clays No. 10 of this section not being represented at Bellevue. This elevation of the lowest member of the Bellevue section (which, at the time of my visit during this survey, was entirely below the level of high-water mark of the Missouri) to something more than 40 feet above the same horizon, on the Platte, in a distance of about five miles, is a tolerably accurate indication of the northeastward inclination of the strata here, though farther south the inclination seems to be to the south of east.

The upper limestone, No. 11, of the section last mentioned, makes good lime, and is much quarried and used in that way, as well as for building purposes, for which it is admirably adapted. Its compact, homogeneous structure, comparative hardness (for a limestone) and uniform pleasing gray tint, are qualities that render it a desirable material even for much of the better kinds of masonry. At present it is much quarried for caps and sills, particularly at Mr. John B. Ducols's place. In looking upon the rather rough, uneven-fractured surface of this rock, without the aid of a magnifier, no one would suspect its true nature and composition. On examining a polished or moistened surface, however, under a lens, it is seen to be composed of millions of *Fusulina* and oolitic particles, embedded in a clear calcareous base. These little bodies are so numerous that they seem to be everywhere in contact, while they are so firmly cemented together that they never separate in breaking the rock, but the fractured surface shows sections of them in every conceivable direction. Larger fossils are sometimes, but more rarely, met with in it.

At Mr. Ducols's quarry, mentioned above, the upper surface of this stratum is everywhere found, on removing the loose overlying superficial deposits, to be perfectly planed off by glacial agencies, as far in as the quarry has been opened; and it is quite probable that comparatively large areas of its upper surface have been thus polished and striated. This is a great puzzle to the quarrymen and others unacquainted with geology; but whether or not the stone-hewers trouble themselves with speculations in regard to its cause, they wisely accept the work thus ready-done to their hands; for, in cutting sills and caps from the upper part of this stratum, they always find one side already dressed more truly and evenly than they can possibly do it with a chisel. But one set of striæ was seen at this locality, and these ranged (by compass) south 10° west. No striated or polished surfaces of this kind were observed by me at any locality south of Platte River; but it is said that they have been seen at some quarries a short distance south of the mouth of that stream.

Boulders, however, of several kinds of granitic and metamorphic rocks, particularly of a kind of red quartzite, showing the action of glacial agencies here, were not unfrequently met with in the country between Platte River and Nebraska City, as well as, occasionally, south of there. These are generally not of large size, though, at one place, about three miles from Nebraska City, in a direction somewhat west of north near Bennett's mill, a huge angular mass of red quartzite was seen lying upon, or rather projecting above, the sloping surface of the ground; for a large portion of it seemed to be embedded. It rises some 10 or 12 feet above the soil, and was estimated to contain not less than 1,000 cubic feet, and perhaps much more. This is evidently a metamorphosed

sandstone, for although now an extremely hard and compact quartzite within, it shows on the slightly-weathered surface indications of planes of stratification. It presents no marks of attrition, but retains all its angles and other irregularities of surface with remarkable sharpness, showing that it must have been transported from its original position on floating ice, or, at any rate, by some agency that did not bring it in contact with other rocks. Small erratic (nearly always angular) masses of this red quartzite have been noticed by Dr. White, in Iowa, and, as he has suggested, there is scarcely any reason to doubt that they have all been transported upon or attached to masses of floating ice during the glacial period, from Southern Minnesota, the nearest point to the northward where rocks of that kind are known to occur *in situ*.

South of Platte River, the first exposure of the Upper Coal-Measure rocks of much extent seen in coming down the Missouri, is just below the town of Plattsmouth, where the following succession of strata may be seen:

Section of the beds exposed at Plattsmouth, with the names of the fossils found in each.

No.	Nature of the strata.	Thickness.
		Ft. In.
9	Slope, apparently composed mainly of Loess Drift, exposing a thickness of	80 0 10 0
8	Hard, yellowish and light-grayish limestone, in heavy beds and thinner layers, with two intercalated seams, 8 to 12 inches in thickness, of ash-colored marly clay, containing millions of *Fusulina cylindrica*; also *Retzia punctulifera, Athyris subtilita, Aviculopecten occidentalis, Entolium aviculatus, Myalina subquadrata, Macrodon tenuistriata, Allorisma subcuneata, Pinna peracuta, Phillipsia major*, &c.	12 9
7	Hard, light-grayish limestones, in thinner layers than the beds above, and containing some flinty concretions.	9 0
6	Ash-colored clay	3 0
5	Black laminated shale	1 6
4	Red clay	6
3	Yellowish incoherent sand	4 0
2	Layers light-colored and yellowish, more or less pure limestone, 10 to 12 inches in thickness, with light-colored and greenish marly clay partings; the whole passing down into light grayish and whitish marly clays, with many thin seams of limestone and numerous fossils. *Fusulina cylindrica, Rhombopora lepidodendroides, Lophophyllum, Synocladia biserialis, Polypora submarginata, Fenestella, Zeacrinus mucrospinus, Eupachycrinus verrucosus, Hemipronites crassus, Chonetes granulifera, C. Verneuiliana, Productus costatus, P. semireticulatus, P. Nebrascensis, P. longispinus, P. punctatus, P. Prattenianus, Spirifer planoconvexus, Sp. lineatus, Syntrilasma hemiplicata, Meekella striato-costata, Sp. cameratus, Spiriferina Kentuckensis, Athyris subtilita, Rhynchonella Osagensis, Retzia punctulifera, Terebratula bovidens, Aviculopecten accidentalis, Bellerophon carbonaria, Euomphalus rugorus, Nautilus ponderosus*, &c.	10 6
1	Green and reddish-brown clays; the former occupying the upper ten inches, and the remainder below being mainly brownish-red, but in places mottled with green.	10 10
	Total of Carboniferous	49 +

At the time we visited this locality, the Missouri was at nearly high-water mark, covering all below the base of the section given above. Professor Marcou, however, visited it when the river was lower, so that he saw below No. 1 about 15 feet of blue shaly clay, with, near its upper part, thin layers of ferruginous limestone; the whole being without fossils.

I found it convenient to group the beds above somewhat differently from the section given by Professor Marcou, and it will also be observed that there is a 4-foot bed of soft sandstone, and 6 inches of black laminated shale in the above section, not mentioned by him. It is not surprising, however, that these should have escaped his attention, because all the beds are so liable to slide and become so mingled and obscured from the undermining of the softer material below, that it is very difficult to make out the exact details of the section. Our opportunities, however, to make out the structure of the outcrop above high-water mark, were better than his, because several drifts and other excavations had a short time previously been made into the cliff here, by parties prospecting for coal, by which means much of the loose *débris* had been removed, so as to show more clearly the nature and arrangement of portions of the section.

To any one having even a limited knowledge of the general principles of paleontology, or of the characteristic fossils of our western Coal-Measures, it must always remain an inscrutable mystery, why Professor Marcou, after visiting this locality, and collecting most of the fossils found in these beds, should have pronounced them the remains of an eminently New Red fauna, allied to the Carboniferous, and referred the rocks to the Lower Permian. This is all the more surprising, when it is borne in mind that every species, with possibly two or three exceptions, yet known from the rocks above the mouth of Platte River referred by him to the Mountain limestone, occurs here at Plattsmouth, while even these exceptions are well-known Coal-Measure species. In addition to this, by turning to the section given on page 90, of the beds exposed three or four miles up Platte River, on the north side, it will be seen that with a few exceptions the same group of fossils found in these so-called Lower Dyassic rocks at Plattsmouth, occur there beneath the same beds called mountain limestone at Bellevue.*

But even Professor Geinitz, who was, from his personal relations with Professor Marcou, naturally inclined to favor his conclusions as much as he could, soon discovered, on examining the collections from Plattsmouth, that the so-called Lower Dyas at that locality was hopeless, because, out of the thirty-three species of fossils composing this so-called "eminently New Red fauna," he found thirty to be Carboniferous forms; and if he had been well acquainted with the fossils of our Coal-Measures, he would have undoubtedly added the other three species, as he might have done several others not included in the collections submitted to him. Indeed, so far from agreeing with Professor Marcou, in viewing these Plattsmouth beds as Lower Dyas, Professor Geinitz even goes to the opposite extreme, and places them in the upper part of the Lower Carboniferous series; though in this he is certainly in error, as I have

* I can only account for Professor Marcou's reference of this section to the Dyas, upon the supposition that the occurrence of a red bed at its base was thought by him to indicate that it belonged to a widely more recent group than the Bellevue and Omaha City outcrops; especially as he gives great weight to lithological characters. Upon this kind of evidence, however, it will be seen by turning to the section of the Omaha boring, given on page 87, that he would have to carry the Dyas down so as not only to include the beds at Omaha, referred by him to the Mountain limestone, but so as to include more than 100 feet of strata below them.

elsewhere shown,* and as any one who has studied the Western Coal-Measure fossils will at once see by examining the list of species, as they form a group especially characteristic of our Upper Coal-Measures of the Western States and Territories.

With regard to the *exact* stratigraphical relations of the section seen on the north side of Platte River, to that just below the town of Plattsmouth, of course we cannot speak very positively, as the beds cannot be traced into contact. Any one, however, who will compare collections of fossils from these two localities, must be at once convinced that the rocks belong to the same series, and must be closely related. Yet it is quite evident that the visible dip of the rocks seen along the north side of the Platte would take them somewhat beneath the Plattsmouth section, though not far below it, as the inclination of the strata here is to the northeastward, while the Plattsmouth exposure is south of east from those mentioned on the north side of Platte River.

At another locality on the Missouri, eight miles south of Plattsmouth, known as Rock Bluff, just above a village of the same name, there is to be seen perhaps the finest exposure of these Upper Coal-Measure rocks anywhere to be found in Nebraska. The lower beds here rise perpendicularly near the base from the river bank, and less precipitously above, exposing, with the exception of one uncovered interval of about 18 feet, about 120 feet of strata. The following is a section of the beds seen here:

Section of the beds exposed at Rock Bluff, on the Missouri, with a statement of the fossils found in each.

No.	Nature of strata.	Thickness.
		Ft. In.
23	Loess or bluff deposit, with possibly toward the lower part some Drift..	150 0
22	Hard yellowish and grayish limestones, in rather thick layers, with some clay partings. *Fusulina cylindrica, Meekella striato-costata, Syntrilasma hemiplicata, Productus costatus, P. semircticulatus, Spirifer lineatus, Sp. cameratus, Athyris subtilita,* &c.	24 0
21	Ash-colored clay 1 foot 9 inches above, underlaid by 1 foot hard gray limestone.	2 9
20	Soft ash-colored or bluish-gray clay, 1 foot, underlaid by black laminated clay, resting upon 1 inch yellow do.	2 1
19	Very compact gray limestone, with an imperfect conchoidal fracture ...	1 6
18	Gray somewhat laminated clay, 4 feet seen, with a 4-foot space below unexposed.	8 0
17	Soft yellowish-gray sandstone, becoming almost loose sand below.....	5 0
16	Not well exposed, but apparently in part occupied by the sandstone seen above, with near the middle and at the base, some bluish clay seen.	18 0
15	Dark-bluish argillaceous limestone. *Aviculopecten occidentalis, Productus Nebrascensis, Edmondia gibbosa.*	1 9

* See Am. Jour. Sci. and Arts, vol. xliv, second ser., p. 335.

No.	Nature of strata.	Thickness.
		Ft. In.
14	Bluish and ash-colored clays, with near the middle a 3 or 4 inch band of red.	8 0
13	Hard light-gray limestone, with apparently oolitic particles. *Allorisma.*	1 6
12	Bluish, ash-colored and purple calcareous clays, with many *Campophyllum*; also *Spirifer cameratus, Zeacrinus hemisphæricus*, &c.	2 0
11	Hard light-gray limestone, with *Aulopora, Fusulina cylindrica, Campophyllum*, &c.	1 0
10	*a.* 7 feet bluish, ash-colored clays; *b.* 20 inches black laminated shale; *c.* 5 feet bluish clay.	13 8
9	Massive heavy-bedded, light-yellowish, rather hard limestone, with some light-colored flinty concretions. *Productus Nebrascenis, P. semireticulatus, Spirifer cameratus, Aviculopecten occidentalis, Pinna peracuta, Allorisma subcuneata, Schizodus, Sedgwickia granosa, Edmondia subruncata, Myalina Swallovi, Petalodus destructor, Peripristis semicircularist*, &c.	5 0
8	Very hard bluish argillaceous limestone. *Chænomya Leavenworthensis* ...	2 0
7	Black laminated shale. *Spirifer planoconvexus*	1 6
6	Light-colored clays, with chalky concretions. *Rhombopora lepidodendroides, Lophophyllum proliferum*, fragments crinoids, *Hemipronites crassus, Orthis carbonaria, Chonetes granulifera, Spirifer planoconvexus, S. cameratus, Spiriferina Kentuckensis, Retzia punctulifera, Rhynchonella Osagensis, Terebratula bovidens, Pinna peracuta, Solenomya, Nucula ventricosa, Euomphalus rugorus.*	5 6
5	Hard light-gray limestone, with minute rounded particles embedded....	1 3
4	Ash-colored and yellowish calcareous clay or marly material. *Fusulina cylindrica.*	0 6
3	Massive, rather compact, light yellowish limestone, with numerous *Fusulina cylindrica*; also curious cavities, apparently left by the cylindrical stems of some marine plant, often abruptly recurved like a horseshoe magnet.	5 0
2	Soft ash-colored marlite, with millions of *Fusulina*; *Fustulipora*, &c.....	1 0
1	Hard, light-grayish heavy-bedded massive limestone, with great numbers of *Fusulina* embedded; also *Spirifer cameratus, Productus Nebrascensis, P. semireticulatus, P. punctatus, P. Prattenianus*, &c.	10 0
	Total of Carboniferous strata	121 0

The lower members, 1, 2, and 3, of this section, with perhaps some other beds beneath the surface of the river at the time of my visit, almost certainly represent, as suggested by Professor Marcou, the upper part of the Plattsmouth section, so that the portion of the section above these may be regarded as a continuation upwards of the section seen at Plattsmouth. Professor Marcou only mentions 60 feet of beds exposed here; but as he does not give a section of these rocks, this is probably only intended as a rough estimate of the thickness of beds exposed at and near the lower extremity of the hill. By following these outcrops

about 150 yards farther up the river, however, I succeeded in ascertaining the nature, thickness, and order of succession of the various beds, with the exception of one unexposed space already mentioned, of about 120 feet of rocks here, above high-water of the Missouri.

The fact that apparently the lower beds, within 10 or 15 feet of the river at this locality, are found nearly 40 feet above the Missouri at Plattsmouth, while there is probably a fall of 5 or 6 feet in the Missouri from Plattsmouth to this locality, shows that there must be a change in the dip of the strata to the southward somewhere near Plattsmouth, as noticed by Dr. Owen. This is also further shown by the entire disappearance of this whole section of more than 120 feet of rocks beneath the level of the river between here and Nebraska City. The dip, however, is probably not due southward, but apparently somewhat east of south.

This section Professor Marcou also referred to the Lower Dyas—that is, to the upper part of the Lower Dyas—while the fossils found here, like those at Plattsmouth, he regarded as representing an eminently New Red fauna. To any person who has studied our Carboniferous fossils, however, the reasons for these conclusions must be very difficult to understand, as it will be at once observed, by a glance at the list of species found in these rocks, that they are precisely the group of forms characterizing our Coal-Measures, strangely enough at some other places referred by Professor Marcou to the Mountain limestone, as elsewhere explained. From this conclusion, however, Professor Geinitz was compelled to dissent, on examining Professor Marcou's collections from this locality, as he very properly referred these beds to the Upper Coal-Measures, to which they unquestionably belong. The strangest thing, however, is, that he should have referred these beds correctly to the Upper Coal-Measures, and the Plattsmouth section to the Lower Carboniferous, when of the thirty-four or thirty-five species of fossils found at Plattsmouth, about twenty-five also occur here at Rock Bluff, while the remaining ten or eleven Plattsmouth forms not yet found at Rock Bluff, are all, excepting two or three that are common to the Coal-Measures and Lower Carboniferous, as already stated, characteristic species of our Coal-Measures, and not yet known to occur at any horizon below the Millstone grit, in this country. He was doubtless led into this inconsistency in consequence of not having a full series of fossils from the two localities for comparison, as he seems to lay some stress upon the occurrence of numerous *Fusulina* at Plattsmouth, this fossil being generally regarded in Russia and Spain as characteristic of the upper part of the Lower Carboniferous series. He was, therefore, evidently not aware of the fact that it also occurs in vast numbers at Rock Bluff, even to the top of the section, and that, so far as yet known, it is in this country peculiar to the Coal-Measures, being most abundant in upper portion referred by Professor Marcou in part to the Dyas, and in part to the Mountain limestone, and has never yet been found in any of our rocks below the Millstone grit.

As at Plattsmouth, several short drifts and other excavations have been here made in search of coal, but, of course, without success, as there is certainly no workable bed, or even less important seam of coal, in this bluff.

Back from the Missouri about six miles, in a southwest direction from Rock Bluff, on a small stream known as Weeping Water, at a locality called Cedar Bluff, there is another very fine exposure of the Upper Coal-Measures, consisting in part of the same strata seen at Rock Bluff. Here the following beds were exposed:

Section of the rocks seen at Cedar Bluff.

No.	Nature of strata.	Thickness.
		Ft. In.
23	Hard, light-gray and yellowish limestone, in rather thick layers. *Fusulina, Athyris subtilita,* crinoid columns, &c. (An excellent building-stone.)	8 0
22	Light yellowish-gray limestone, in parts hard, but generally softer than that above; and in irregular layers of various thickness.	8 0
21	Greenish-blue clay	1 6
20	Light-grayish limestone, more impure and less compact than the next limestone below. *Hemipronites crassus.*	8
19	Laminated clay, green above, darker below	1 6
18	Hard, light-gray limestone	1 8
17	Light-colored calcareous marlite, with seams of whitish hard limestone above.	8
16	Soft, yellowish sandstone, in some parts laminated; possibly also occupying some of the unexposed space below.	12 0
15	Unexposed, excepting a little greenish laminated clay about 4 feet above base.	15 0
14	Brownish-red clay	3 0
13	Light-yellowish and ash-colored clays, with some thin layers of soft impure limestone.	6 0
12	Brownish-red clay	3 0
11	Greenish clay. *Chonetes, Spirifer cameratus, Campophyllum*	1 0
10	Hard, light-bluish gray or whitish limestone, with green clay partings. *Campophyllum torquium.*	2 0
9	Greenish and yellowish clays	3 0
8	Reddish-brown clays, with one 4-inch band of bright green	3 6
7	Green crumbling clay	1 2
6	Yellowish clay with light-yellow calcareous concretions	1 0
5	Hard, bluish-gray, rather pure limestone	1 3
4	Soft, bluish argillaceous limestone, with at base 18 inches green clay	8 0
3	Light-grayish shaly clay, with a streak of black above	1 0
2	Black laminated shale	2 2
1	Dark-bluish argillaceous limestone, and indurated clay	3 3
	Total	88 +

Having but a comparatively short time to devote to examinations here, only a few fossils were collected from the beds in place, but the following species were found among the *débris* at the base of the bluff, that had evidently fallen from the rocks cropping out above, viz: *Scaphiocrinus hemisphæricus, Zeacrinus mucrospinus, Lophophyllum proliferum, Campophyllum torquium, Hemipronites crassus, Chonetes, Productus Nebrascensis, P. costatus, Syntrilasma hemiplicata, Athyris subtilita, Rhynchonella Osagensis, Spirifer (Martinia) planoconvexus, S. (M.) lineatus ? (= perplexus, McC.,) Spiriferina Kentuckensis,* the fragment of *Pseudomonotis* figured on Plate II, (Fig. 9), and *Euomphalus rugosus.*

This exposure was not visited by Professor Marcou, but there can be no doubt that he would have referred it to the Dyas if he had seen it, as it presents the same general lithological characters as the outcrops at Plattsmouth and Rock Bluff, with some differences in the details, and evidently belongs to the same series of Upper Coal-Measures. I am inclined to believe, however, that it represents that portion of the Rock Bluff section above bed No. 9. These beds all show a dip of a few degrees to the south, or southeast.

The upper beds here afford a good building-stone, and have been found to make good lime, while the sandstone, No. 16, is at places so soft and incoherent that it can be easily dug out and applied to most of the purposes for which sand is used. The bed of black slate at the base of the section was at one time supposed to be a sure indication that valuable coal mines might be found there, and caused the land to be held, and, if I am not mistaken, to be sold, at a high price. It is evident, however, that no coal of any value exists in this outcrop.

At Wyoming, on the Missouri, twelve miles in a direction a little west of south, below Rock Bluff, a low exposure of rocks crops out on the immediate margin of the river, showing the following beds:

Section at Wyoming, with an enumeration of the embedded fossils.

No.	Nature of strata.	Thickness.
		Ft. In.
6	Blue and red clay, entire original thickness unknown. *Productus semireticulatus, Syntrilasma hemiplicata, Athyris subtilita, Chonetes granulifera, Productus Nebrascensis, Spirifer (Martinia) planoconvexus, Hemipronites crassus, Spiriferina Kentuckensis, Rhynchonella Osagensis, Pleurophorus occidentalis, Bellerophon carbonaria, Euomphalus rugosus,* &c.	4 0
5	Hard gray, impure silicious limestone. *Fusulina cylindrica, Syntrilasma hemiplicata,* fragments crinoids, &c.	2 0
4	Light grayish ash-colored clay. *Hemipronites crassus, Syntrilasma hemiplicata, Chonetes granulifera, Meekella striato-costata, Spirifer cameratus, Productus longispinus, Spirifina Kentuckensis, Spirifer (Martinia) planoconvexus,* &c.	3 6
3	Massive hard yellowish, or light-gray silicious limestone, somewhat argillaceous below. *Schizodus, Allorisma, Pinna peracuta, Fusulina,* &c.	4 0
2	Bluish and ash-colored laminated, calcareous clays.....	5 0
1	Red gritty clay, passing down into a soft red sandstone, more or less micaceous, ripple-marked and concretionary.	9 0
	Total.....	27 6

All these beds show a slight inclination to the southward or southeastward. On the upper surface of bed No. 3, I saw the same kind of curious markings, apparently of the cylindrical stems of some marine plant (often curved like a horseshoe magnet,) mentioned as occurring in bed No. 3, at Rock Bluff. The beds here at Wyoming, however, appear to hold a higher position in the series, judging from the southeastward dip of the strata here and at Cedar and Rock Bluffs, than any of the beds at either of the former localities. Professor Marcou places them on a parallel with the lower part of the section seen at Nebraska City, and I am inclined to believe they belong to that horizon, or at least very near it, in the series. He includes them, however, as a part of the Upper Permian, or Dyas, and in this Professor Geinitz concurs with him, though all the fossils yet found here occur also in the very beds referred by the latter author at Plattsmouth to the Lower Carboniferous, and all but about five of them in the same beds at Omaha and Bellevue referred by Professor Marcou to the Lower Carboniferous; while even the four species occurring here, that have not yet been found at Omaha or Bellevue, such as *Meekella striato-costata*, *Bellerophon carbonaria*, *Syntrilasma hemiplicata*, and *Pinna peracuta*, are well-known Coal-Measure species. In short, there is not the slightest reason, if we can place any reliance whatever upon fossils in identifying and determining the position of strata, for separating this outcrop from the Upper Coal-Measures.

About four miles in a nearly south direction from Wyoming, and three miles in a northwest direction from Nebraska City, at Bennett's Mill, there is to be seen along a small stream, probably 90 to 100 feet below the summit of the immediately surrounding country, an exposure showing the following beds:

Section at Bennett's Mill.

No.	Nature of strata.	Thickness.
		Ft. In.
4	Hard silicious, light-gray limestone, at some places in two layers, with a clay parting between; and although compact within, showing indications of a laminated structure on weathered surfaces. *Rhombopora lepidodendroides*, *Fusulina cylindrica*, *Syntrilasma hemiplicata*, *Spirifer (Martinia) planoconvexus*, *Rhynchonella Osagensis*, *Chonetes granulifera*, *C. glabra*, *Productus longispinus*, *Spirifer cameratus*, and teeth of *Peripristis semicircularis*.	2 6
3	Light drab and ash-colored clays	3 0
2	Band of soft drab argillaceous limestone, containing *Productus Prattenianus*, *P. punctatus*, *Chonetes granulifera*, *Spirifer cameratus*, *Syntrilasma hemiplicata*, *Scaphiocrinus (?) hemisphæricus*, *Myalina subquadrata*, *Aviculopecten occidentalis*, *Pinna peracuta*, *Allorisma subcuneata*, *Pseudomonotis* sp., *Allorisma* sp. and *Chomatodus arcuatus*.	0 8
1	Light grayish crumbling indurated clay, of which about two feet were exposed.	2 0

These beds Professor Marcou and Professor Geinitz regard as occupying the same horizon as those seen at Wyoming, and the lower part of the Nebraska City section, which is doubtless very nearly or quite correct. I cannot concur with them, however, in including these rocks

in the Permian, for the reasons already stated in regard to the Wyoming and other outcrops.

About two miles down the same little stream, in an east direction from Bennett's Mill, the same beds are seen at a somewhat lower level in the bed of the creek. Here the following fossils were found: *Rhombopora lepidodendroides*, *Fistulipora*, *Scaphiocrinus hemisphæricus*, *Hemipronites crassus*, *Syntrilasma hemiplicata*, *Chonetes granulifera*, *Meekella striato-costata*, *Productus semireticulatus*, *P. longispinus* (?), *Athyris subtilita*, *Spirifer cameratus*, *Spirifer (Martinia) planoconvexus* and *Platyceras*. (See Plate IV, Fig. 15, *a. b.*)

The next locality at which these rocks were examined was at the Nebraska City landing, where the following succession of beds may be seen:

Section of beds exposed at the Nebraska City landing, with an enumeration of the fossils found in each.

	Nature of strata.	Thickness.
		Ft. In.
	Loess or bluff deposit, consisting of fine light-grayish pulverulent silicious and more or less calcareous clay or marl, without distinct marks of stratification; rising back to a height of 80 to	90 0
D.	Yellowish-gray micaceous, soft sandstone, laminated or in thin ripple-marked layers, excepting 12 to 15 inches of the lower part, which is sometimes hard and compact; with fragments of plants.	10 0
C.	Drab, ash, and lead-colored, and reddish-brown clays, with, near the middle, a 9 or 10-inch hard bluish-gray argillo-calcareous layer, weathering to a rusty color. Fossils numerous, particularly near the lower part, as follows: *Rhombopora lepidodendroides*, *Lophophyllum proliferum*, *Scaphiacrinus* (?) *hemisphæricus*, *Eocidaris Hallianus*, *Synocladia biserialis*, *Fenestella Shumardi*, *Polypora submarginata*, *Glauconome trilineata*, *Lingula Scotica* (?), *Hemipronites crassus*, *Syntrilasma hemiplicata*, *Chonetes glabra*, *C. granulifera*, *Productus pertenius*, *Productus longispinus* (?), *P. Prattenianus*, *P. Nebrascensis*, *P. symmetricus*, *P. semiretriculatus*, *Rhynchonella Osagensis*, *Spirifer cameratus*, *Spirifer (Martinia) planoconvexus*, *Spiriferina Kentuckensis*, *Athyris subtilita*, *Lima retifera*, *Entolium aviculatum*, *Aviculopecten carbonarius*, *A. neglectus*, *A. Coxanus*, *A. occidentalis*, *Myalina Swallovi*, *M. subquadrata*, *Avicula longa*, *Avicula* (?) *Sulcata*, *Aviculopinna Americana*, *Pseudomonotis radialis* (? ?), *Nucula Leyrichi* (? ?), *Nucula ventricosa*, *Yoldia subscitula*, *Nuculana bellistriata*, *Macrodon tenuistriata*, *Solenomya* sp., *Solenopsis solenoides*, *Pleurophorus oblongus*, *Schizodus curtus*, *S. Wheeleri*, *Schizodus* sp., *Modiola subelliptica*, *Edmondia reflexa*, *E. Nebrascensis*, *E.* (?) *glabra*, *Prothyris elegans*, *Allorisma* (*Sedgewickia*) *subelegans*, *A.* (*S.*) *Geinitzii*, *A. reflexa*, *Dentalium Meekianum*, *Bellerophon Montfortianus*, *B. percarinatus*, *B. Marcouanus*, *B. carbonaria*, *Euomphalus rugosus*, *Orthonema subtæniata*, *Aclis Swalloviana*, *Pleurotomaria Haydeni*, *P. subdecussata*, *P. Marcouana*, *P. Grayvillensis*, *Orthoceras cribrosum*, *Nautilus occidentalis*, *Cythere Nebrascensis*, and *Cythere* sp.	39 0
B.	Several beds of hard, light-grayish, and yellowish limestones, in layers of from five to twenty inches in thickness, with soft, marly clay seams and partings. Fossils: *Fusulina cylindrica*, *Rhombopora lepidodendroides*, *Lophophyllum proliferum*, *Erisocrinus typus*, *Synocladia biserialis*, *Hemipronites crassus*, *Orthis carbonaria*, *Meekella striato-costata*, *Syntrilasma hemiplicata*, *Chonetes granulifera*, *Chonetes glabra*, *Productus longispinus* (?), *P. semireticulatus*, *P. costatus*, *P. Prattenianus*, *P. Nebrascensis*, *P. symmetricus*, *Rhynchonella Osagensis*, *Spirifer* (*Martinia*) *planoconvexus*, *S. cameratus*, *Athyris subtilita*, *Retzia punctulifera*, *Pinna peracuta*, *Myalina subquadrata*, *Allorisma subcuneata*, *Euomphalus rugosus*, *Bellerophon carbonaria*, *Phillipsia scitula*, *Cladodus mortifer* and *Deltodus* (?) *angularis*.	12 0

	Nature of strata.	Thickness.
		Ft. In.
A.	*a.* Lead-gravish and greenish clay, 4 feet	8 0
	b. Reddish-brown ferruginous, slightly gritty, indurated clay, 4 feet exposed above high-water mark.	
	Total below drift	69 0

Fusulina cylindrica, mentioned among the fossils of bed B above, was not found by us in that bed immediately at the Nebraska City landing, but it occurs in this bed at Bennett's Mill and Wyoming; also in beds referred to this horizon by Professor Marcou, one and three-fourths mile and two and a half miles west of the outcrops at the landing, at elevations of from 73 to 80 feet above low-water of the Missouri. We also found it in a limestone cropping out of the bluff one mile below (southeast of) the Nebraska City landing, at a higher geological horizon than bed D, of the above section. The following other fossils, not yet found in bed B, at Nebraska City, occur in it at Bennett's Mill and Wyoming, as shown in the sections at those places: *Scaphiocrinus (?) hemisphæricus*, *Zeacrinus mucrospinus*, *Entolium aviculatum*, *Aviculopecten occidentalis*, *Pseudomonotis* sp., *Pleurophorus occidentalis (?)*, *Peripristis semicircularus* and *Chomatodus arcuatus*.

In the foregoing section I have adopted the principal divisions recognized by Professor Marcou, and for convenience have also followed him in using letters instead of numbers, to designate the several divisions. He made other more minute subdivisions, but however well it may be to do this in first examining such exposures, with a view of keeping separate the fossils coming from each subordinate bed or seam, so soon as we know which beds are merely local modifications of color, hardness, &c., and which are more persistent and recognizable at other localities by their lithological characters and the grouping of their fossils, such minute local details had better, in comparing sections, be dispensed with, as they make the sections more complex and less easily compared.

By a glance at the list of fossils found in the bed B, it will be at once seen that with the exception of some five or six species (which are themselves well-known Coal-Measure forms), we have here all of the very same species found in the Bellevue and Omaha beds referred by Professor Marcou to the mountain limestone, and along with them a number of other species, forming altogether a group peculiarly characteristic of the western Coal-Measures, which Professor Marcou would also insist upon making mountain limestone, in Iowa, Missouri and Illinois.

This list of species, it will likewise be observed, not only includes such types as the foraminiferous genus *Fusulina*, Corals, Crinoids, Brachiopods, &c., but also Lamellibranchs, Gasteropods, and the Carboniferous and older genus *Phillipsia*, as well as Carboniferous genera of fishes. For these reasons, I must repeat that I cannot concur with Professors Marcou and Geinitz, in separating these beds from the Coal-Measures and including them in the Permian or Dyas, merely because a few such forms as *Pseudomonitis*, *Plurophorus*, and *Schizodus*, closely allied to, or possibly even in some cases identical with, European Permian species, are occasionally met with in them.

On ascending to division C, we also meet with a large proportion of the same fossils found in B, along with a considerable number not here *found in the latter* division. These, however, as will be seen farther

on, are nearly all species that occur elsewhere in the Coal-Measures of the western States. Consequently I can see no reason whatever for drawing any important line of division between the beds included in C and those of B, or for separating either from the Coal-Measures.

The following beds were seen at Mr. Morton's and Mr. Werth's places near Nebraska City, but with the base of the outcrops elevated 73 to 80 feet above the Missouri.

*Section 1¾ and 2¾ miles due west of Nebraska City.**

No.	Nature of strata.	Thickness.
		Ft. *In.*
5	Slope consisting of 50 or 60 feet of Loess, at the base of which some slabs of ripple-marked micaceous sandstone were seen apparently nearly in place.	60 0
4	Bluish, greenish and drab clays, showing about 19 feet.....	19 0
3	Bluish impure argillaceous limestone, some parts very hard, others decomposing and shaly. *Fusulina cylindrica, Scaphiocrinus (?) hemisphæricus, Rhombopora lepidodendroides, Hemiproutes crassus, Chonetes granulifera, C. glabra, Spirifer (Martinia) planoconvexus, Spiriferina Kentuckensis, Athyris subtilita, Spirifer cameratus, Rhynchonella Osagensis, Syntrilasma hemiplicata, Productus costatus, P. semireticulatus, P. symmetricus, P. longispinus (?), Myalina subquadrata, Euomphalus rugosus,* &c.	2 0
2	Black bituminous shale, with a few inches of coal. Some of the same fossils in the shale as those in the bed above.	1 6
1	Blue laminated clay; only a few inches exposed.	

The group of fossils found in No. 3 here, it will be seen, agrees exactly, so far as they go, with that of division B of the section at the landing, with the exception of *Fusulina*, which is quite abundant here, but, as already stated, is not yet known to occur at the Nebraska City exposures, though found in division B, at Wyoming and Bennett's Mill. The rocks themselves, however, do not correspond with those composing the section at the landing, in their composition and other characters. The clays of No. 4, it is true, might correspond to a part of division C at Nebraska City, and the loose masses of ripple-marked sandstone might be supposed to have slidden from a bed agreeing with division D, but the other beds below are so different from any of those forming the lower part of the Nebraska City section, as to give rise to doubts as to their identity. At least I saw nothing there representing the black shale and coal seen at Mr. Morton's and Mr. Werth's places.

Another fact pointing to the conclusion that the beds forming the foregoing little section probably hold a higher position than those seen at the Nebraska City landing, is the occurrence of an outcrop agreeing almost exactly with the former, at a locality one mile below Nebraska City, in a southeast direction, at an elevation of 30 *feet above high water*. Here the same black shale with seams of coal is seen, with blue and ash-colored clays below, and immediately above it a hard bluish-gray argil-

* Professor Gienitz alludes to the locality at Mr. Morton's as being four miles west of Nebraska City. I am informed, however, by the engineer who ran the level between the Nebraska City landing and this outcrop at Mr. Morton's, that the distance is 1¾ miles, and the elevation 73 feet.

laceous limestone 30 inches in thickness, with *Fusulina*, *Hemipronites crassus* and fragments of other fossils, while immediately above the limestone greenish and bluish clays were seen for some 15 feet in place, with pieces of bluish argillaceous rock lying loose. Now, as this outcrop is just about one mile from the landing, and almost exactly in the direction of the dip, it cannot of course belong to any position below the beds seen at the landing, without there should be a reverse of the dip, or a fault here, of which there is no evidence whatever; while the beds themselves are entirely different from any part of that section. Hence it seems almost morally certain that this is the same limestone, black shale, coal, &c., seen at Mr. Morton's and Werth's places, brought down to within 30 feet of the Missouri at this place, by a gentle southeast dip, the distance from Mr. Morton's to this point being about two and three-quarter miles. If these are the same beds seen at Mr. Morton's, then the place they occupy here, one mile southeast of the Nebraska City outcrops, almost exactly in the direction of the dip, and yet at an actual elevation of 30 feet above the base of the outcrop at the landing, it would follow that the beds seen at Mr. Morton's and Mr. Werth's hold positions a little higher in the series than the top of the Nebraska City section, and of course that there is here a recurrence of nearly the same fauna above division C, as that found beneath it, in division B, at the landing. On the other hand, if these beds of shale, coal and limestone, seen one mile below Nebraska City, are not the same seen at Mr. Morton's, they must hold a still higher stratigraphical position; and, as they correspond to nothing in the Nebraska City section, they would at least establish the existence of the genus *Fusulina* above the horizon of division C at Nebraska City landing. It will also be seen farther on that the outcrop at Otoe City, doubtless correctly placed by Professor Marcou above the horizon of division C, contains great numbers of *Fusulina*, with various other Coal-Measure types, and, so far as yet known, none of the Permian forms.

It is to be regretted that in sinking a shaft at Mr. Morton's, to a depth of nearly 100 feet, commencing nearly on a level with the base of the outcrop alluded to, no memorandum of the thickness of the various beds and seams passed through was kept. A great number of hand specimens of the material penetrated, consisting of various-colored clays, arenaceous matter, &c., with some limestones, were carefully preserved, but, unfortunately, it was impossible to obtain any more reliable information in regard to the exact thickness and order of succession of the numerous layers penetrated than could be given from memory by the workmen; while the planking up of the shaft prevented the possibility of any information of this kind being derived from a direct examination.

It is worthy of note here, that some of the clays shown to us from the shaft, agree very well, in color and other respects, with those of division C, at the Nebraska City landing, and some of these specimens also contained a group of fossils very rarely found *together* in any other horizon than that division—such, for example, as *Chonetes glabra*, *Aviculopecten carbonarius*, *Bellerophon Marcouianus*, &c. All the fossils found in the material removed in excavating this shaft are figured together on Plate IV. No coal was struck, but at near the bottom of the shaft a black, bituminous shale, 3 feet in thickness, containing the impression of a Calamite, was penetrated. Immediately under this, a hard, white limestone, 3 feet in thickness, was also passed through.

As a means of forming some conclusions in regard to the nature of the *strata* beneath the surface of the Missouri at Nebraska City, the fol-

lowing statement of an artesian boring, made at this locality, is given. This boring was made in the valley of the river, about one mile below the landing, commencing about 13 feet above high-water mark.

*Mr. Croxton's boring at Nebraska City.**

No.	Nature of strata penetrated.	Depth.	
		Ft.	*In.*
1	Alluvial	17	0
2	Limestone	2	8
3	Gray shales	6	0
4	Sandstone	1	4
5	Limestone	2	0
6	Blue shales	2	0
7	Red shales	15	0
8	Limestone	1	0
9	Red and buff shales	7	0
10	Limestone	2	0
11	Shale	3	0
12	Limestone	1	0
13	Red sandstone	4	0
14	Gray shales	8	0
15	Red shales	5	0
16	Gray shales	20	0
17	Micaceous sandstones	8	0
18	Blue limestone	1	0
19	Buff shales	3	0
20	Gray shales	12	0
21	Red sandstone	4	0
22	Red shales	3	0
23	Gray shales with intercalations of various kinds of rock, sulphuret of iron (smutty, according to miners) and traces of petroleum.	65	0
24	Blue limestone	5	0

* The different beds passed through in this and the other artesian borings, are numbered from above downward; while those of the sections examined above the horizon of the Missouri, are numbered from below upward.

No.	Nature of strata penetrated.	Depth. Ft.	In.
25	Coal	1	3
26	Clay and shale	13	0
27	Red shale	3	0
28	Calcareous sand	1	0
29	Blue slate rock	1	4
30	Red shales	1	0
31	Limestone with hard seam	0	10
32	Black slate	1	0
33	Brown shales	3	0
34	White limestone, very fine texture	6	0
35	White limestone	7	0
36	Gray shales	7	0
37	White sandstone, fine texture	3	0
38	Blue limestone	5	0
39	Coarse gray sandstone, (salt water)	5	0
40	Fine freestone	4	0
41	Shale	3	6
42	White limestone	6	0
43	Hard brown shale	3	0
44	Fossiliferous calcareous shale	1	0
45	Gray soft shale	1	6
46	Calcareous sand-rock	4	0
47	White lime or marl	16	0
48	Blue limestone	3	6
49	White shales or marl	3	0
50	Pyritiferous rock	2	0
51	White shales or marl	3	9
52	Crinoidal limestone	1	6
53	Brown shale or slate	2	0
54	Buff shale	2	0

No.	Nature of strata penetrated.	Depth.
		Ft. *In.*
55	Blue shales	10 0
56	Gray and white shales	15 0
57	Gray slate	2 0
58	Black slate	—2 0
59	Limestone	5 0
	Total	344 2

I had no opportunity to examine the borings from this well, and have to rely entirely upon the memorandum kept by those conducting the work. Although it is probable, for reasons elsewhere intimated, that the details of the section may not be exactly correct in all respects, it doubtless gives a good general idea of the strata penetrated, and is important as a demonstration that no workable beds of coal exist here beneath the level of the Missouri Valley, within nearly 350 feet of the surface. It also confirms other evidences of a southeastern dip here, because it is evident that the beds numbered 2, 3, 4, 5, 6 and 7, near the top of the boring, are the same as divisions A and B, of the section at the landing; and as they rise there nearly 20 feet above high water, and are here found entirely below that horizon, the evidence becomes quite conclusive as to the dip. It also shows that the *Fusulina* limestone cropping out of the hill 30 feet above high water, some 150 yards farther down, and in the direction of the dip, must hold a position above the whole of the section seen at the landing.

After leaving the immediate vicinity of Nebraska City, no exposures of rocks in place were observed, until we arrived at Otoe City, about five and a-half miles farther down the river, in a direction east of south. Here we saw the following beds exposed:

Section of the beds exposed at Otoe City.

No.	Nature of strata.	Thickness.
		Ft. *In.*
	Loess, with some Drift at the base	40 0
11	Soft, yellowish sandstone	10 0
10	Drab and ash-colored, with seams and concretions of arenaceous matter	3 0
9	Bluish laminated clays, passing gradually into the next bed below	7 0
8	Nearly black laminated clay or shale, with sometimes between it and the bed above a 6 to 8-inch bed of yellow limestone in the shale. *Productus Prattenianus, P. longispinus (?), Sp. (Martinia) planoconvexus, Rhynchonella Osagensis, Chonetes granulifera, Spiriferina Kentuckensis, Productus semireticulatus, Hemipronites crassus.*	—3 0
7	Very hard, dark-gray calcareous layer	4

No.	Nature of strata.	Thickness.
		Ft. *In.*
6	Red, green, blue, and light ash-colored clays, with near the base a 2 or 3-inch seam of black shale.	58 0
5	Soft, drab, marly material, becoming in parts hard and compact, or with hard, calcareous seams. Millions of *Fusulina cylindrica;* also, *Chonetes granulifera, Hemiphronites crassus, Spirifer cameratus, Spiriferina Kentuckensis, Syntrilasma hemiplicata, Meekella striato-costata, Productus semireticulatus, Myalina perattenuata.*	3 0
4	Light drab laminated clay, with a streak of black; at one place seen to swell out, so as to form a bunch of coal, 6 to 8 inches thick, with efflorescence of sulphate iron.	1 6
3	Soft, incoherent, yellowish sandstone	6 0
2	Soft, bluish, sandy shale, with large, round, and compressed oval concretions.	5 0
1	Bluish and drab clays, in parts more or less arenaceous. *Productus Prattenianus.*	15 0
	Total, exclusive of Loess and Drift	111 —

It is proper to state here, that the whole of this section was not seen in one uninterrupted exposure. All the beds from No. 1 up to, and including 8 feet of No. 6, are seen in regular succession immediately above the site of the deserted village called Otoe City. The remaining portion above was seen in another exposure about a quarter of a mile above the village, with just enough uncovered space below (allowing for a gentle inclination of the strata) to receive the beds seen immediately above the village, and, as but a moderate southeast dip was observed here, there is scarcely any reason to doubt the propriety of regarding the two exposures as directly succeeding each other in the vertical series.

At the time this section was examined, the Missouri was nearly at high-water mark. I was informed by a gentleman living in the village, however, that the bluish-drab clays forming No. 1, continue on down 12 to 13 feet farther than the base of the section as given above, and that beneath the whole there is a dark bluish-gray limestone, of which I saw some pieces containing *Hemipronites crassus.*

If the southeast dip observed near Nebraska City is continued in this direction to this place, it is quite probable that the dark-bluish gray limestone seen at low water here at the base of the Otoe City section, is the same seen cropping out over the black shale and coal, 30 feet above the Missouri, one mile below Nebraska City.* If so, it would apparently make the whole of the Otoe City section newer than the beds seen at the Nebraska City landing. This would agree nearly with the opinion expressed by Professor Marcou,† who, if I understand him correctly, thinks the lower beds here, up to No. 5 inclusive, of the foregoing section, the same as division D of the section at Nebraska City, and some 10 feet

* Professor Marcou gives the distance from Nebraska City to Otoe City as twelve miles south; in this he probably means by the curves of the steamboat channel of the Missouri River, as it is only about five and a half miles by a direct line, and in a southeast direction.

† Bull. Geol. Soc. France, XXI, new ser., p. 137.—1864.

of the bed No. 6 exposed in the bluff at Otoe City, a part of the highest bed of the Dyas. He seems not to have seen the other beds, forming the upper part of the section between a quarter and a half mile farther up the river. He also appears to have made the identification entirely from lithological characters, as neither he nor Professor Geinitz, who investigated his collections, mentions any fossils from this locality, while all of those yet known from this outcrop are, as may be seen by the names in the section, the same Coal-Measure types so often mentioned at other localities. So it will be seen we have here additional evidence to that mentioned in connection with the statement of facts observed at and near Nebraska City, that there are above the horizon of division C at Nebraska City section, repetitions of the same Coal-Measure group of fossils, seen in the beds below, including millions of *Fusulina*, with *Chonetes granulifera*, *Productus semireticulatus*, *P. Prattenianus*, *Spirifer cameratus*, *Spiriferina Kentuckensis*, *Hemipronites crassus*, *Rhynchonella Osagensis*, *Syntrilasma hemiplicata*, *Meekella striato-costata*, &c., while none of the Permian types have yet been found here!

At the village of Peru, five miles in southeast direction, below Otoe City, about a quarter to a half mile above the landing, beds of light-colored limestone, 12 to 18 inches in thickness, crop out of the side of the slope 90 to 100 feet above high water. A little lower some loose masses of limestone, that have apparently slidden from the beds above, have been dug out for building purposes. From the disintregrated limestone, or associated shaly matter, we picked up loose, many specimens of *Spirifer* (*Martinia*) *planoconvexus*, *Sp. cameratus*, *Productus Nebrascensis*, *P. longispinus*, *Athyris subtilita*, *Spiriferina Kentuckensis*, *Hemipronites crassus*, *Euomphalus rugosus*, &c. Lower in the hill indications of red clays were seen, though not well exposed, the whole hill being probably composed of the same, or at any rate, a part of the same, beds exposed at Otoe City.

Less than a quarter of a mile, however, below the village of Peru, there is an abrupt exposure of yellowish and light-gray, soft, somewhat micaceous sandstone, with large, round and compressed or oval concretions of arenaceous matter, of considerable hardness. There are also very curious irregularly and obliquely arranged seams and isolated masses of dark-bluish shaly matter and clay. These appear as if the sandstone had been very irregularly eroded in places during its deposition, and the shaly matter deposited in the depressions, and then more sand upon it again. Fragments of coal were also seen embedded in the sandstone, along with stems of Calamites, and broken-up leaves of ferns. The sandstone can scarcely be said to be stratified, but appears massive with the exception of some oblique marks of deposition, and the intercalated seams of shaly matter. The latter are not continuous for any distance, but often end very abruptly, or in other cases become much attenuated, and again swell out to a foot or so in thickness. They do not appear to conform to the bedding of the sandstone, but cut obliquely across it at various angles, and yet their laminated structure, and fragments of plants, show they were deposited in water. This exposure of sandstone rises abruptly from the edge of the river at high water, to an elevation of about 60 to 65 feet, and almost certainly holds a lower stratigraphical position than the outcrops of limestone seen 90 to 100 feet above the Missouri, a short distance above the village. Its position is doubtless nearly the same as that of the lower part of the Otoe City section, though it is more arenaceous here, and perhaps thicker. Just over it some red clay was seen, apparently a little slidden from its proper position.

At the time of *our visit, the Missouri* being high, no beds below this

sandstone were exposed above water. Dr. Owen, however, mentions seeing beneath evidently the same bed, either here or near here, a black bituminous shale, and brown encrinital limestone.

As an additional evidence that this sandstone holds a lower position in the series than the limestones mentioned high in the hill above the village, we may mention that at a locality about two and a half miles west of south from here, and a mile or so back from the river, at a higher elevation than the sandstone, there are outcrops of light-colored limestone agreeing exactly with those seen cropping out in the hill above the village. In the rubbish thrown out at a quarry in these beds, we found *Spirifer (Martinia) planoconvexus*, *Sp. cameratus*, *Chonetes granulifera*, *Pleurophorus* sp., fragments of *Myalina*, *Pleurotomaria* sp., *Bellerophon carbonaria*, *B. Montfortianus*, &c.

At Brownville, about five miles below Peru, in a direction east of south the following outcrops were seen:

Sections of the various beds exposed at Brownville.

No.	Nature of strata.	Thickness.
		Ft. In.
14	Loess rising back with the slope from 30 or 40 to	100 0
13	Dark-bluish, very fine unctuous clay, becoming nearly black below, and weathering to drab color. *Aviculopecten Whitei*, *Spirifer (Martinia) planoconvexus*, *Productus pertenuis*, small *Polyphemopsis*, *Pleurotomaria*, *Macrocheilus*, *Myalina perattenuata*, and *Nuculana* sp. (Seems to be merely the remains of a thicker bed.)	2 0
12	Yellowish-gray, granular or sub-oolitic limestone; massive, but showing a disposition to divide into two layers.	3 0
11	Unexposed	10 0
10	Whitish, soft argillaceous limestone, 6 to 8 inches thick	0 8
9	Red, purple, and greenish clays	10 0
8	Whitish and yellowish impure limestone, rather massive. *Allorisma subcuneata*, stems of crinoids, *Bellerophon percarinatus*, *Productus Nebrascensis*, &c.	3 0
7	Purple clay	1 0
6	Soft, whitish limestone	6 0
5	Bluish clay	5 6
4	Black shale and seams impure coal, with impressions fern leaves	1 0
3	Blue clay, with fragments of coal and iron pyrites	20 0
2	Black, hard rock, with crystals calc spar	2? 0
1	Soft, yellowish micaceous sandstone, with irregular seams and alternating laminæ of black and greenish, more or less carbonaceous and sandy material, with fragments of coal. Many broken leaves of ferns, pieces of *Calamites*, &c. *Neuropteris hirsuta*, *Neuropteris Loschii* (identified by Professor Lesquereux), and Coprolites of some Selachian fish, as determined by Professor Agassiz.	57

Of the lower member of this section only about 25 feet were exposed above high water of the Missouri, when examined. I was informed, however, by an intelligent gentleman who sunk a shaft into it through several of the overlying beds, that they penetrated it to a depth of 57 feet without passing through it. Several persons also stated that when the Missouri is low, branches and trunks of trees are seen in this rock, which, judging from their descriptions, are probably *Lepidoderon* and *Sigillaria*.

This is doubtless the same sandstone seen just below Peru, about five miles in a direction west of north from here. If so, there must be a moderate dip in this direction, or the bed is not so thick, as it only rises at this place about 25 feet above high water, while its summit there was 65 feet above the river, and there must be 3 or 4 feet fall in the river in that distance.

Of the beds filling the interval between Nos. 1 and 4, of the foregoing section, I only saw the upper part of No. 3, but they were described to us and their thickness given by the gentleman who sunk the shaft already mentioned, through them.

'A little below the landing at Brownville, and not more than 100 yards in a southeast direction from where the sandstone No. 1 of last section is seen, showing a thickness of 25 feet above high water, 5 or 6 feet of greenish fine arenaceous clay was seen at the base of the hill, not more than 6 or 7 feet above the level of the river. Above this greenish clay, about the same thickness of reddish-brown clay occurs. Just over the latter fragments of whitish argillaceous limestone were lying, as if they had slidden down from a decomposing bed of the same. Among these great numbers of *Fusulina* and *Chonites granulifera* were found loose; also fragments *Spirifer cameratus*, *Productus semireticulatus*, &c. Above this some beds of red clay, and in parts green, are imperfectly exposed, and still higher, or about 50 feet above high water of the Missouri, some thin beds of whitish, crumbling, impure limestone, and light-drab clay are imperfectly exposed. Among the loose fragments of the limestone were found *Chonetes granulifera*, *Productus semireticulatus*, *P. longispinus*, *P. Nebrascensis*, and some stems of crinoids. Immediately above the crumbling limestone some indications of a thin bed of black shale were observed, while the remainder of the hill (some 60 to 70 feet above) seemed to be composed entirely of Loess.

It is probable all these beds of clay and limestone had slidden some from their proper horizons, as it would require a greater dip than we have reason to believe exists here, to bring the whole of the 25 feet of sandstone seen above high-water mark, just above the Brownville Landling, beneath the base of the hill here, only about 100 yards farther down the river.

Between one and two miles below Brownville, along the same line of bluffs, the following exposures were seen:

Section one and a half miles below Brownville.

No.	Nature of strata.	Thickness.
		Ft. In.
8	Loess rising back with the slope from 30 or 40 to.....	10 0
7	Bluish, fine clay, a few inches only remaining; apparently same as No. 13 at Brownville.	0 0
6	Yellowish, granular *sub-oolitic limestone*.....	0 10

No.	Nature of strata.	Thickness.
		Ft. In.
5	Ash-colored clay, with whitish calcareous seams, more or less indurated, with some blue and red clays below.	8 0
4	Yellowish-gray, impure, sub-oolitic limestone	2 0
3	Red and bluish clays	10 0
2	Whitish, impure limestone. *Productus Prattenianus*	0 10
1	Red, bluish, and ash-colored clays, with loose fragments of whitish limestone strewed along the upper part of slope from the bed above; also loose *Productus longispinus* (?), *P. Nebrascensis*, *Sp. cameratus*. Near base great numbers of *Chonetes granulifera;* with *Myalina subquadrata*, *Bellerophon percarinatus*, &c. The whole of this bed not very clearly exposed.	43

These exposures indicate a continuation of the upper part of the Brownville section, the lower sandstone being probably mainly below the level of the Missouri here. It is worthy of note that the beds 4 and 6 here agree exactly in structure, color, and composition, with the two layers composing No. 12 of the Brownville section, but here they are separated by about 8 feet of clays, represented at Brownville, in same position, by a mere seam, which is at other places wanting. This illustrates the changes liable to occur in the beds of these rocks in comparatively short distances.

At Aspinwall, seven miles below Brownville, in a direction slightly east of south, we had an opportunity to examine various outcrops, from which the following section was constructed:

Sections of beds exposed at Aspinwall.

No.	Nature of strata.	Thickness.
		Ft. In.
15	Loess varying in thickness from 30 to	40 0
14	Grayish and drab clays, with thin seams of light-colored calcareous matter.	6 0
13	Massive, rather hard, yellowish limestone. Numerous *Myalina peracuminata;* also *Aviculopecten occidentalis*, *Hemipronites crassus*, *Allorisma subcuneata*, *Productus Nebrascensis*, *Edmondia Aspinwallensis*, *Euomphalus rugosus*, *Nautilus occidentalis*, &c.	3 0
12	Bluish and drab clays, with one or more 6 to 8-inch seams soft, grayish, impure limestone.	20 0
11	Yellowish limestone	1 6
10	*a.* Bluish clay, 5 feet *b.* Red clay, 5 feet *c.* Bluish laminated clay, 3 feet	13 0
9	Bluish and whitish impure limestone. *Productus longispinus* (?), *Chonetes granulifera*, *Athyris subtilita*, *Hemipronites crassus*, *Spirifer* (*Martinia*) *planoconvexus*, *Meekella striato-costata*, *Productus pertenuis*, *Productus semireticulatus*, *Spiriferina Kentuckensis* and a tooth of *Xystodus* (?) *angularis*.	4 0

No.	Nature of strata.	Thickness.
		Ft. In.
8	Coal	0 6
7	Clay	2 0
6	Bluish indurated clay	4 0
5	Hard, bluish, impure limestone	1 6
4	Black shale	4 0
3	Coal	1 10
2	Bluish clay	15 0
1	Sandstone, above low water	3 0
	Total below Loess	78 10

At the time of my examination, No. 1, and part of No. 2, of this section were concealed by high water. No. 3 was seen rather imperfectly a little below its true horizon, owing to the slipping of a part of the outcrop from undermining by the river. Nos. 4, 5, 6, 11, and 12 were more or less perfectly exposed, and 13 was very clearly seen. All the information in regard to the thickness, order of succession, &c., of the other beds not seen by me, was obtained from an intelligent miner who has made various excavations into the hill, and stripped off the loose material at places, so as to be able to see all the beds in their proper positions. Most of these openings were covered again by slides, and the falling in of the clay, loose rocks, &c., at the time of my visit. The fossils from No. 9 were found in fragments of the rock thrown out of a shallow shaft.

The miner working here says all these beds have a perceptible dip up the river, north or northwest, as he has determined by sinking a shaft at a point a little north of the main exposure, and he thinks the whole section passes beneath that seen at Brownville. The dip, however, may be local, as the beds here above No. 8 appeared to me very like those composing the imperfect exposures seen a short distance below Brownville. He says the bed of coal No. 3 and associated rocks, agree exactly with those seen at Clorinda, Page County, Iowa, where he has been engaged in mining coal.

It will be observed that this bed of coal is the thickest one yet seen in any natural exposure, or struck in any of the shafts or borings in these rocks. As near as can be determined from specimens taken from the rather weathered outcrop, it seems to be of good quality, and preparations are being made to mine it. It is not easy to determine yet, whether it can be profitably mined. It certainly could not, I should think, in a district where thicker beds are accessible, as it will probably be necessary to remove most of the overlying rather soft black shale in working it, in order to have a solid roof that can be timbered up, if not to give working space. Another disadvantage is that it cannot be conveniently mined at the outcrop along the bluff, owing to the tendency of all the beds of the lower part of the section to slide down, in consequence of the river washing away the soft underlying beds. Consequently, they will *have to sink a shaft 70 to* 80 feet in depth, back from

the river some little distance. In a country like this, however, with such a vast area of fertile soil, capable of sustaining a dense population, where there is at present a deficiency of wood, it is probable that this coal may be profitably mined, unless better and more extensive beds may be found within workable distances by sinking deep shafts in this region, which seems doubtful.

The rocks seen here at Aspinwall were also, like those at Brownville, Peru, and other localities along this part of the Missouri, referred by Professor Marcou to the Permian (= Dyas), but upon what evidence he does not say, nor is it apparent to any one who regards fossils as any guide in identifying rocks, as those found here consist of the same forms constituting the group so often mentioned as characterizing the Coal-Measures of the Western States.

At Arago, about fourteen miles southeast from Aspinwall, I saw at the base of the hill, near 12 feet above the Missouri, some 7 inches of yellow limestone, containing *Productus longispinus*, and a small *Myalina;* and over this 18 inches of hard, compact bluish limestone, containing *Productus punctatus*, *Chonetes*, *Pinna*, *Entolium aviculatum*, &c. Above the latter some bluish clays were seen, and some large masses of impure bluish limestone that had slidden from a higher bed, with numerous *Fusulina*, were lying along the slope.

Two miles above Rulo, and some six or seven miles in a direction east of south from Arago, the following outcrop was examined:

Section two miles above Rulo on the Missouri.

No.	Nature of strata.	Thickness.
		Ft. In.
7	Loess with perhaps some Drift seventy to	80 0
6	Massive yellow limestone	5 0
5	Gray and yellowish impure limestone and drab clays	4 6
4	Bluish and drab arenaceous clay with fossil ferns. *Neuropteris hirsuta* and *N. Loschii.*	7 0
3	Coal	0 6
2	Indurated clay, called soapstone by the miners. (Not seen)	0 4
1	Bluish laminated sandstone, very soft, with thin streaks of black, and looking very much like No. 1 of the Brownville section.	8 0

I did not see the whole of No. 1 of this section, it being partly covered by the high water of the Missouri, though I was informed by a miner at work in a drift immediately over it, that he had seen as much as 8 feet of it exposed. The whole of this exposure seemed to me to have bodily slipped a little below its true horizon, probably from the washing away of the soft sandstone beneath by the river. This appearance is also confirmed by the statements of the miners, who informed me that the coal ends and all the beds change abruptly at the end of the drift, 40 to 50 feet in. The thickness, composition, and order of succession of the beds, however, can be very clearly seen. Of course any attempt to mine so thin a seam

of coal by drifting in and removing a portion of the clays above, will hardly be remunerative, and there is little or no reason for believing that it will be found materially to increase in thickness farther in the hill.

At another locality, one and a quarter miles south of Rulo, and at an elevation of about 25 feet above high water of the Missouri, a shaft and boring were sunk to a depth of about 76 feet. The shaft was filled with water at the time of our visit, but the miner who sunk it, Mr. St. Louis, gave the following statement of rocks perforated:

Shaft and boring one and one-fourth miles south of Rulo.

No.	Nature of strata penetrated.	Depth. Ft.	In.
1	Yellow indurated clay, called soapstone by the miners	18	0
2	Yellow limestone	3	0
3	Blue clay. In this clay, lying near the shaft, we found the following fossils: *Rhombopora lepidodendroides*, an incrusting species of *Fistulipora*; *Polypora submarginata*, *Hemipronites crassus*, *Productus Nebrascensis*, *P. Prattenianus*, *Chonetes granulifera*, *Syntrilasma hemiplicata*, *Spirifer* (*Martinia*) *planoconvexus*, *Sp. cameratus*, *Nucula* (?) sp., *Pleurophorus* sp., *Bellerophon Kansasensis*, *Bellerophon* sp., *Naticopsis* sp., *Pleurotomaria perhumerosa*, and several undetermined species of *Murchisonia*.	12	0
4	Hard, gray limestone	11	0
5	Blue clay	17	0
6	Limestone	3	0
7	Blue clay bored into below the limestone	12	0
	Total	76	0

In another shaft, sunk only about 30 yards south of the above, and commencing at a horizon about 20 feet lower, we were informed a bed of coal 16 inches thick was struck at a depth of 17 feet. It seems difficult to account for this bed not having been struck in the other shaft, sunk so near, to a depth of 76 feet. The miner thought that it was to be accounted for by the northern dip of the strata, but this is scarcely possible, as no evidence whatever of such high inclination of the strata was observed in some beds of yellow *Fusulina* limestone seen cropping out of the slope a little above the horizon of the deeper shaft, though there seems to be good evidence of a moderate northern dip here. If there was no mistake in all the facts given, there is probably a fault here, though it may be the case that the disagreement between the beds observed in the two shafts was produced by a sliding down of some of the beds penetrated in the 17-foot shaft at some distant period, when the Nemaha (in the valley of which this latter shaft was sunk) ran close along the base of the hill at this place, as often takes place in these rocks.

At the mouth of the Great Nemaha, a mile or two farther down the Missouri, Dr. Hayden saw an exposure (the same mentioned by Dr. Owen) of soft sandstone rising 20 or 30 feet above the river, with above it a thin (5 or 6-inch) seam of coal connected with arenaceous shales,

containing the same ferns found over the bed of coal two miles above Rulo, and at Brownville.

The elevation of this coal and sandstone here above the Missouri shows there is quite a perceptible rising of the strata in this direction, the same coal being only about 8 feet above the river two miles above Rulo, though it had apparently slidden somewhat below its true horizon at the latter place. I am inclined to believe this sandstone under the coal the same bed seen at Peru and Brownville, and at the base of the section at Aspinwall, though it may be another holding a lower position. If it is the same, there can be little doubt but the exposures here near Rulo hold a position in the series above the horizon of the Nebraska City section. On these points, however, more detailed examinations than we had an opportunity to make are desirable.

With the completion of the observations here in the vicinity of Rulo, ended our examinations of the rocks seen along the Missouri in Nebraska, between Omaha City and the southern boundary of the State. As some deep borings, however, had been made at St. Joseph, Missouri, and Atchison, Kansas, it seemed desirable that all the facts revealed by these borings should be noted and taken into consideration in connection with those observed along the Missouri in Nebraska above; consequently these two places were visited on my return eastward.

The distance between Rulo, in the southeast corner of Nebraska, and St. Joseph, in Missouri, is, by an air line, about thirty-three miles, the direction from the former to the latter being nearly due southeast. Along this interval I made no examinations, though it is evident from the observations of Dr. Owen, Professor Swallow, and particularly those of Mr. Broadhead, that Coal-Measure rocks, characterized by the same fossils already so often mentioned, form, with the overlying Loess, the hills bounding the Missouri Valley, as above Rulo. It is probable, however, that the rise of the strata below Rulo brings up a considerable thickness of rocks between that place and St. Joseph that are not seen at or near Rulo. If I understand Mr. Broadhead's section correctly, he recognizes about 700 feet of strata altogether, as rising up between the sandstone at the mouth of Great Nemaha and St. Joseph, Missouri. From his description of these rocks, I have little doubt that they include the whole or a part of the Nebraska City section, and all of the beds bored through at that place, composed in part of the Rock Bluff and Plattsmouth sections. There may, however, be here a considerable thickness of intercalated strata not represented as far north as Nebraska City, as there are evidences of a thickening of the series toward the south. The fact that all of these rocks rise up from beneath the sandstone at Nemaha, which may be the same seen at Peru, believed to hold a higher stratigraphical position at least than the division C at Nebraska City, favors the view expressed, while the few fossils mentioned by Mr. Broadhead in these rocks at least show them to belong mainly to the same Coal-Measures series. These are, *Fusulina cylindrica*, *Chætetes*, *Hemipronites crassus*, *Syntrilasma hemiplicata*, *Productus Nebrascensis*, *P. Prattenianus*, *Athyris subtilita*, *Spiriferina Kentuckensis*, *Myalina subquadrata* and *Aviculopecten carboniferus*. Mr. Broadhead used different, but synonymous, names for several of these fossils.

While at St. Joseph I visited a place about one mile, a little west of north from the city, where a shaft had been sunk (commencing, perhaps, some 70 or 80 feet above the Missouri) to a depth of about 100 feet, in search of coal. Judging from the material thrown out, for more than half the distance it had penetrated through Loess, of which there *are heavy deposits* here. Beneath this they struck fine, rather bright

lue indurated clay, more or less laminated, and showing some minute pecks of mica on the partings. This evidently belongs to the coal eries, and not to the Drift or Loess. From the quantity thrown out, it vas probably penetrated to a depth of about 40 feet, and of course below he level of the Missouri, without passing through it, or striking any oal or beds of limestone, or other hard rock.

At another locality two miles south of St. Joseph the deep boring, to vhich allusion has already been made, was sunk. For the following tatement of the various beds penetrated, and for the privilege of examining specimens of the borings from most of the beds, I am under obligations to T. B. Weakley, esq., of St. Joseph, one of the gentlemen at vhose expense the boring was made.

ection of a boring two miles south of St. Joseph, 60 feet above high water of the Missouri.

o.	Nature of strata penetrated.	Depth.	
		Ft.	*In.*
1	Loose surface material. [Loess and soil]	21	0
2	Blue clay, (with specks of mica)	74	0
3	Sandstone	16	0
4	Soapstone. [Indurated clay]	10	0
5	Limestone	4	0
6	Soapstone. [Indurated clay]	2	0
7	Slate	2	0
8	Coal	— 1	2
9	Bituminous shale	6	0
10	Limestone	7	6
11	Slate	5	0
12	Limestone	6	0
13	Black slate	2	0
14	Limestone	4	6
15	Black shale or slate	5	6
16	Limestone	1	0
17	Slate	14	0
18	Limestone	4	6
19	Hard soapstone. [Indurated clay]	3	0
20	Sandstone	2	6

No.	Nature of strata penetrated.	Depth. Ft.	In.
21	Soapstone. [Indurated clay]	2	6
22	Limestone	4	9
23	Dark-bluish slate	24	0
24	Bluish-gray limestone	12	0
25	Slate	6	0
26	Bituminous shale	1	6
27	Blue slate	8	0
28	Limestone	4	0
29	Slate and shale	20	0
30	Light-gray or drab limestone	6	0
31	Green slate	20	0
32	Bluish limestone and clays	40	0
33	Coal	1	0
34	Blue soapstone. [Indurated clay]	3	8
35	Bluish-gray slate or indurated clay	4	6
36	Light-bluish gray and darker limestone	16	6
37	Light-blue soapstone. [Indurated clay]	3	0
38	Coal	2	0
39	Light-drab limestone	9	0
40	Marble. [Compact limestone]	4	0
41	Limestone	3	0
42	Slate	2	6
43	White limestone	2	6
44	Blue marley clay	14	0
45	Bluish-drab soapstone. [Indurated clay]	7	0
46	Slate	38	0
47	Limestone	10	6
48	Soapstone. [Indurated clay]	15	0
49	Light-gray limestone	20	0
	Total	496	7

The bed of blue clay (No. 2 of the boring) is almost certainly the same struck in the shaft, one mile above St. Joseph, as the borings from it agree well with the clay thrown out at the shaft. It is probably the most extensive bed of that character in the whole series, and may possibly represent the 40-foot bed, No. 19, called "blue slate," in the Omaha boring.

Between St. Joseph and Atchison, Kansas, I had no opportunity to make any examinations; but Mr. Broadhead's explorations of these rocks along the Missouri side of the river show a continuation of the same great series of Coal-Measures without any workable beds of coal. The distance between these two places is, by a right line, about seventeen miles, and the direction from St. Joseph to Atchison very nearly due southwest.

At Atchison, and along the bluffs between there and "Riverside," the residence of Mr. George Scarborough, just above the village of Sumner, and three miles below Atchison, I had an opportunity to make out very satisfactorily (with the exception of one unexposed interval of 17 feet) a continuous section of Coal-Measure beds, altogether more than 175 feet in height above the Missouri.

During my examinations here, I was materially aided by Mr. Scarborough, whose taste for geological and botanical investigations had previously led him to explore the surrounding country, so as to be able to direct my attention to the best exposures, and otherwise to assist me in making out the following section of the rocks at this locality.

Section of the rocks exposed at Riverside, Kansas, and along the river bluff between there and the Atchison Landing.

No.	Nature of strata.	Thickness. Ft.	In.
22	Slope, probably Loess, to the summit of highest point, known as Prospect Hill.	27	0
21	Rough, yellowish limestone, splitting into thin pieces on weathered surfaces; great numbers of *Fusulina*.	2	0
20	Blue clay below, yellow above	2	0
19	Two layers yellowish-gray limestone with 18 inches clay between	5	6
18	Ash-colored clays with *Chonetes granulifera*	2	6
17	Black, thinly laminated bituminous shale	2	6
16	Hard, impure, yellowish-gray limestone	2	0
15	Blue clay	6	0
14	Soft, yellowish limestone	3	0
13	Grayish limestone weathering to yellow, in two layers, upper 1 foot, lower 20 inches. *Fusulina*.	2	8
12	Bluish and ash-colored, more or less laminated and sandy clays, with near the top a 2½-inch seam of impure coal, or carbonaceous matter.	11	6

No.	Nature of strata.	Thickness. Ft.	In.
11	Yellowish and gray or bluish-gray sandstone; some parts very soft, but a few layers very hard and breaking almost like quartzite; the soft part sometimes laminated, and in others in 10 to 12 inch layers.	23	0
10	Unexposed	17	0
9	Hard, bluish-gray, impure limestone. *Productus Nebrascensis, P. pertenius, Chonetes granulifera, Athyris subtilita.*	2	6
8	Unexposed space	21	0
7	Hard, bluish-gray, impure limestone, some parts argillaceous, others a little arenaceous. *Productus Nebrascensis, P. Prattenianus, Athyris subtilita.*	4	0
6	Bluish laminated clay, with near the top two or three hard calcareous layers.	5	0
5	Bluish and light-grayish limestones, weathering to yellowish, in irregular layers, with thin gray and yellowish partings. Many *Fusulina, Productus Nebrascensis, P. Prattenianus, Spirifer cameratus, Sp. lineatus (?), Athyris subtilita, Pinna peracuta, Avicula longa, Allorisma subcuneata, Syntrilasma hemiplicata, Schizodus,* and teeth of *Cladodus.*	16	0
4	Yellowish and drab laminated clays	2	6
3	Black, regularly laminated shale	2	6
2	Hard, bluish-gray, argillaceous limestone, weathering to yellowish in places. *Fusulina cylindrica, Hemipronites crassus, Chonetes glabra, Productus Prattenianus, P. longispinus (?), Edmondia subtruncata, Aviculopecten occidentalis, Bellerophon crassus,* &c.	1	10
1	Bluish and drab-colored, more or less laminated, clay, with near the top many *Chonetes granulifera;* also *Myalina* sp.	42	0
	Total Coal-Measures	175	6

Eight or ten feet of No. 1 of this section were under water at the time the examinations were made, and the nature of that part was learned from Mr. Scarborough and other persons at Atchison. At the Atchison Landing, the top of the heavy stratum of limestone, No. 5, which forms a well-marked horizon, is a little more than 65 feet above high water of the Missouri, while at Mr. Scarborough's place, (Riverside), three miles below Atchison, in a direction east of south, its upper layers are 100 feet above high water. Allowing 2 feet for the slope of the river surface in that distance, it would leave a difference of 37 feet in the actual elevation of the various corresponding beds at Atchison and Riverside, showing a dip here to the northwestward of a little more than 12 feet to the mile.

At first I was unable to reconcile this with the boring two miles below St. Joseph, at which point it seemed probable this conspicuous bed of limestone should have been struck in the boring near the level of the Missouri. On reflecting, however, that the direction from Atchison to the locality where the boring below St. Joseph was made, although up the river, is not north, but a little east of northeast, while the dip of the

strata here is northwest, or possibly a little west of northwest, it will be seen that the heavy bed of blue clay struck in the St. Joseph boring, at an elevation of 39 feet above the Missouri, almost certainly holds a stratigraphical position a little below the horizon of the 16-foot bed of limestone mentioned above. This conclusion is strengthened by the occurrence of a heavy bed of bluish and drab laminated clay beneath the 16-foot bed of limestone at Atchison, as well as by the fact that another boring at Atchison, commenced 22½ feet above high water of the Missouri, and about 12 feet below the above-mentioned limestone, after passing through 15 feet of loose earth and fragments of rock (debris of the limestone in the hill above), struck shale, or laminated clay, and passed through a thickness of 11 feet of it. The "conglomerate rock," No. 3, 5 feet in thickness, mentioned in the memorandum of the Atchison boring, beneath the laminated clay, is doubtless the same sandstone, No. 3, of the St. Joseph boring, with some of the very hard concretions so often seen in the sandstones of this series. The want of exact agreement of thickness and composition of this and other beds penetrated, is easily accounted for by the changes so common in the lithological characters of the beds composing this series, and the different methods of grouping the subordinate beds, at the two borings.

For the following statement of the boring at Atchison, I am under obligations to George W. Glick, esq., of Atchison, the president of the company that sunk the boring:

Boring at Atchison, Kansas, commencing 22½ feet above high-water mark of the Missouri; made by the Atchison Coal Company, 1865–'66.

No.	Nature of strata penetrated.	Depth.	
		Ft.	*In.*
1	Loose earth and fragments of rock	15	0
2	Shale, (laminated clay)	11	0
3	Conglomerate rock, [so called by the workmen]	5	0
4	Bituminous shale with a little coal	19	0
5	Sandy mixed shale	82	0
6	Hard limestone	8	0
7	Gray shale	1	6
8	Sandstone, very hard	2	1
9	Sand and shale	7	0
10	Shale, clayey and sandy	27	0
11	Dark-brown clay, with small seam of coal	8	0
12	Sandy shale	1	0
13	Gray shale with sand-rock at bottom	7	0
14	Bituminous shale	6	0
15	Hard lime-rock	21	0
16	Soapstone. [Indurated clay]	—1	6

No.	Nature of strata.	Depth. Ft.	In.
17	Very hard rock	3	0
18	Shale with a little coal	3	0
19	Sandy ironstone	1	6
20	Gray shale	9	0
21	Lime-rock		6
22	Shale	5	0
23	Lime-rock	1	0
24	Gray shale	4	0
25	Lime-rock	2	0
26	Shale with coal	1	0
27	Lime-rock	3	0
28	Hard lime-rock	10	0
29	Soapstone. [Indurated clay]	2	0
30	Lime-rock.	4	0
31	Sandy shale	2	0
32	Hard lime-rock	0	4
33	Sandy shale	2	0
34	Sand-rock	5	0
35	Hard shale	3	0
36	Sandstone	0	6
37	Shale	10	0
38	Hard rock	1	6
39	Shale	3	0
40	Lime-rock	2	0
41	Shale, (hard)	4	0
42	Sand-rock	0	6
43	Lime-rock	4	6

If I am not mistaken, this boring, as already suggested, commenced at very near the same geological horizon as that at St. Joseph, and, as far as it went, merely explored, at least in part, the same ground as that penetrated at St. Joseph, allowing for the thinning out of some unim-

portant beds, and the thickening or change in the composition of others. If so, the money expended on the Atchison boring added little or nothing to the information developed by that at St. Joseph. If it is, therefore, desired to make further explorations at either of these localities, I would advise that the St. Joseph boring be carried 500 or 600 feet deeper, and if a workable bed of coal should be struck there, it may reasonably be expected to exist at not far from the same depth beneath Atchison.

Having thus given a somewhat detailed sketch of the various natural sections of these rocks seen along the Missouri, in Nebraska, below Omaha City, together with statements of the thickness, order of succession, and included fossils of the numerous subordinate beds, along with the facts revealed by the several shafts, drifts, borings, and other excavations examined, it will be interesting to consider the vertical range of the different types of organic remains so often mentioned, and their relations to those of our Carboniferous rocks elsewhere, with the view of throwing some light upon mooted questions respecting the age of some of these Nebraska strata.

In order to facilitate such a review of the range of the fossils already mentioned in detail in their proper places in the several sections given, the following tabular list of all the species has been prepared. With regard to the abbreviations, Kans., Mo., Io., Ill., W. Va., and Ky., inserted in the columns after the names, it is perhaps scarcely necessary to explain that they are used instead of the names of the several States, Kansas, Missouri, Iowa, Illinois, West Virginia, and Kentucky.*

The other columns designate localities in Nebraska at which the various species have been found. For the species found at Nebraska City two separate columns are used, to show which forms occur in the division B and which in C, the line of separation between these two divisions being more strongly marked upon paleontological grounds *at this particular locality* than others, though in some parts of the West the fossils of both divisions are, with few exceptions, known to range through the whole series.

As it would be inconvenient, as well as unnecessary, for the proposed objects of comparison, to give a separate column for each of the numerous localities at which the fossils enumerated were found, only a few of the more prominent localities are thus noted, and these are the particular localities at which the outcrops occur that have been by Professors Marcou and Geinitz referred in part to the Lower Carboniferous, and in part to the Coal-Measures and Permian (= Dyas). In the column on the right, some additional localities are also occasionally noted, and of these it is proper to remark that the outcrops at Otoe City, Aspinwall, Brownville, and Peru are believed to hold a higher position in the series than division C, at Nebraska City. That at Otoe City was so regarded by Professor Marcou, in which opinion I am, as elsewhere stated, inclined to agree with him, and there are equally good grounds for believing the beds seen at Peru, Aspinwall, and Brownville are in part or entirely upon the same horizon, or very near it, as these Otoe City outcrops.

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* The comparatively small number of Illinois, Missouri, Iowa, Kansas, and Nebraska species, noted in the Kentucky column, is due to the fact that little attention was devoted, during the progress of the Kentucky survey, to collecting fossils. So far as the Coal-Measure fossils of Kentucky are known, however, the remains of both animals and plants agree very closely with those of Illinois, as might be expected from the exact correspondence shown by Lesquereux to exist between the various beds composing this series in *these two States*.

Tabular list, illustrating the geological and geographical range of the fossils of Eastern Nebraska.

No.	Names of species.	COAL-MEASURES IN OTHER STATES.						ESPECIAL LOCALITIES IN NEBRASKA.						Miscellaneous localities in Nebraska.
		Kans.	Mo.	Io.	Ill.	Ky.	W. Va.	Omaha.	Bellevue.	Platts-mouth.	Rock Bluff.	Nebraska City, Wyoming, Bennett's Mill. B	Nebraska City, Wyoming, Bennett's Mill. C	
	PLANTS.													
1	*Neuropteris hirsuta*, Lesqx.[1]	.....	.....	.....	Ill¶	Ky.	.....	.....	.....	.....	.....	.....	.....	Brownville and two miles above Rulo.
2	*Neuropteris Loschii*, Brgt	.....	.....	.....	Ill¶	.....	.....	.....	.....	.....	.....	.....	.....	Do.
3	*Calamites*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Brownville.
	ANIMAL REMAINS.													
4	*Fusulina cylindrica*, Fischer	Kans.	Mo..	Io.	Ill¶	.....	.....	*	*	*	*	.....	.....	Nebraska City, above bed C; Otoe City; Brownville, Rulo, &c.
5	*Rhombopora lepidodendroides*, Meek	Kans.	Mo..	Io.	Ill¶	.....	.....	.....	*	*	*	*	*	North side Platte, Rulo.
6	*Fistulipora*, undt. sp	Kans.	Mo..	Io.	Ill¶	.....	.....	.....	*	*	*	*	.....	Rulo.
7	*Syringopora multattenuata*, McCh	.....	.....	...	Ill¶	.....	.....	.....	.....	.....	.....	.....	.....	3 miles up Platte River, north side.
8	*Lophophyllum proliferum*, McCh., (sp.)	.....	Mo..	Io.	Ill¶	.....	.....	.....	.....	*	*	*	*	Do.
9	*Campophyllum torquium*, Owen, (sp.)	.....	Mo..	Io.	Ill¶	.....	.....	.....	.....	.....	*	.....	.....	Cedar Bluff.
10	*Scaphiocrinus? hemisphæricus*, Shm	Kans.	Mo..	Io.	Ill¶	.....	.....	*	.....	.....	.....	*	*	3 miles up Platte, north side; Cedar Bluff.
11	*Zeacrinus mucrospinus*, McCh	Kans.	Mo..	Io.	Ill¶	.....	.....	.....	.....	*	.....	.....	.....	Cedar Bluff.
12	*Erisocrinus typus*, M. & W	.....	.....	Io.	Ill	.....	.....	.....	*	.....	.....	?	.....	
13	*Archæocidaris triserratus*, M	.....	.....	...	Ill	.....	.....	*	.....	.....	.....	.....	.....	Three miles up Platte River.
14	*Eucidaris Hallianus*, Geinitz	.....	.....	...	.....	—	.....	.....	.....	.....	.....	.....	*	
15	*Fenestella*, sp	.....	.....	...	Ill¶	.....	.....	.....	*	*	.....	.....	.....	
16	*Fenestella Shumardi*, Prout	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	*	
17	*Polypora submarginata*, Meek	.....	.....	...	Ill¶	.....	.....	.....	.....	*	.....	*	*	
18	*Polypora*, sp	Kans.	.....	Io.	.....	.....	.....	.....	.....	.....	.....	.....	*	
19	*Synocladia biserialis*, Swallow[2]	Kans.	?	Io.	Ill¶	.....	.....	.....	.....	*	.....	*	*	Three miles up Platte River.
20	*Glauconome trilineata*, Meek	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	*	
21	*Glauconome Americana*, Swallow, (sp.)	Kans.	.....	Io.	Ill	.....	.....	.....	.....	.....	.....	*	.....	
22	*Lingula Scotica*, Davidson?	.....	.....	...	Ill	.....	.....	.....	.....	.....	.....	.....	*	
23	*Orbiculoidea*, sp	.....	.....	...	Ill¶	.....	.....	.....	.....	.....	.....	.....	.....	Morton's shaft, 1¾ miles west of Nebraska City.
24	*Chonetes Verneuiliana*, N. and P	Kans.	Mo..	Io.	Ill¶	.....	.....	.....	.....	*	.....	.....	.....	Three miles up Platte River.
25	*Chonetes granulifera*, Owen	.....	Mo..	Io.	Ill¶	.....	.....	*	*	*	*	*	*	Cedar Bluff, Otoe City, Rulo, &c.
26	*Chonetes glabra*, Geinitz	Kans.	?	Io.	.....	.....	.....	.....	.....	.....	.....	*	*	Morton's shaft, Nebraska City.
27	*Productus pertenuis*, Meek	Kans.	.....	...	Ill¶	.....	.....	.....	.....	.....	.....	*	*	Morton's.
28	*Productus Nebrascensis*, Owen	Kans	Mo..	Io	Ill¶	Ky..	W. Va	*	*	*	*	*	*	Platte River, Brownville, Rulo, &c.
29	*Productus symmetricus*, McCh	Kans.	Mo..	Io	Ill¶	.....	.....	.....	*	.....	.....	*	*	Platte River and other localities.
30	*Productus punctatus*, Martin, (sp.)	Kans	Mo..	Io	Ill¶	.....	.....	.....	*	*	*	*	.....	Morton's shaft.
31	*Productus costatus*, Sowerby	Kans.	Mo..	Io.	Ill¶	Ky.	.....	*	*	*	*	*	.....	

32	*Productus semireticulatus*, Martin, (sp.)	Kans.	Mo..	Io	Ill¶	.....	W. Va.	*	*	*	*	*	*	Otoe City, Brownville, Aspinwall, &c.
33	*Productus longispinus*, Sowerby	Kans	Mo..	Io.	Ill¶	Ky.	.....	*	*	*	*	*	*	Do.
34	*Productus Prattenianus*, Norw	Kans	Mo..	Io	Ill¶	Ky..	W. Va	*	*	*	*	*	*	Otoe City, Rulo, &c.
35	*Hemipronites crassus*, M. and W	Kans	Mo..	Io	Ill¶	Ky..	W. Va	.....	*	*	*	*	*	Platte River, Otoe City, Aspinwall, Rulo.
36	*Meekella striato-costata*, Cox, (sp.)	Kans	Mo..	Io	Ill ..	Ky..	.....	.....	.....	*	*	*	.....	Otoe City, Aspinwall.
37	*Syntrilasma hemiplicata*, Hall, (sp)	Kans	Mo..	Io	Ill ..	.....	.....	.....	.....	*	*	*	*	Otoe City, Rulo, &c.
38	*Orthis carbonaria*, Swallow	Kans	Mo..	Io	Ill¶	.....	.....	.....	.....	.....	*	*	.....	Platte River.
39	*Rhynchonella Osagensis*, Swallow	Kans	Mo..	Io	Ill¶	.....	.....	.....	*	*	*	*	*	Platte River, Otoe City.
40	*Spirifer cameratus*, Morton	Kans	Mo..	Io	Ill¶	Ky..	W. Va	*	*	*	*	*	*	Otoe City, Brownville, Rulo.
41	*Sp. (Martinia) plano-convexus*, Shum.	Kans	Mo..	Io	Ill¶	?	W. Va	.....	*	*	*	*	*	Platte River, Otoe City, Brownville.
42	*sp. (Martinia) lineatus*, Martin, (sp.)	Kans	Mo..	Io	Ill¶	.....	.....	.....	*	*	*	.....	.....	
43	*Spiriferina Kentuckensis*, Shum	Kans	Mo..	Io	Ill¶	Ky..	.....	*	*	*	*	*	*	Otoe City, Aspinwall.
44	*Retzia punctulifera*, Shum	Kans	Mo.	Io	Ill¶	Ky..	.....	.....	.....	*	*	*	.....	
45	*Athyris subtilita*, Hall, (sp.)	Kans.	Mo..	Io	Ill¶	Ky..	W. Va.	*	*	*	*	*	*	Aspinwall.
46	*Terebratula boridens*, Morton	Kans	Mo..	Io.	Ill¶	.....	.....	.....	.....	*	.....	.....	.....	Platte River.
47	*Lima retifera*, Shumard	Kans	.....	...	Ill¶	.....	.....	.....	.....	.....	.....	.....	*	
48	*Entolium aviculatum*, Swallow, (sp.)	.....	Mo..	Io.	Ill¶	.....	.....	.....	.....	*	.....	*	*	Do.
49	*Nucula Beyrichi*, V. Schaur?[1]	.....	.....	...	Ill¶	.....	.....	.....	.....	.....	.....	*	*	
50	*Nucula ventricosa*, Hall	Kans	?	Io.	Ill¶	.....	W. Va	.....	.....	.....	*	.....	*	
51	*Yoldia subscitula*, M. and W?	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	*	
52	*Naculana bellistriata*, Stevens, (sp.)	Kans	.....	Io	Ill¶	.....	W. Va	.....	.....	.....	.....	.....	*	Brownville.
53	*Macrodon tenuistrata*, M. and W	.....	.....	Io	Ill¶	.....	.....	.....	.....	.....	.....	.....	*	
54	*Schizodus curtus*, M. and W	Kans	.....	...	Ill¶	.....	.....	.....	.....	.....	.....	*	*	
55	*Schizodus Wheeleri*, Swallow, (sp.)	.....	Mo..	Io	Ill¶	.....	.....	.....	.....	.....	*	.....	*	Platte River.
56	*Schizodus*, sp	.....	?	...	Ill¶	.....	.....	.....	.....	.....	.....	.....	*	
57	*Avicula longa*, Geinitz, (sp.)	Kans	.....	Io	Ill¶	.....	.....	.....	.....	.....	.....	.....	*	
58	*Avicula? sulcata*, Geinitz	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	*	
59	*Pseudomonotis*, sp.[2]	?	.....	...	Ill ..	.....	.....	.....	.....	*	.....	*	.....	Cedar Bluff.
60	*Pseudomonotis radialis*, Phill., (sp.) ?[2]	.....	.....	...	Ill ..	.....	.....	.....	.....	.....	.....	.....	*	
61	*Myalina Swallovi*, McChesny	Kans	Mo..	Io	Ill¶	.....	.....	.....	.....	.....	*	.....	*	
62	*Myalina subquadrata*, Shum	Kans	Mo..	Io	Ill ..	.....	W. Va	.....	*	*	.....	*	*	Platte River.
63	*Myalina perattennata*, M. and W	Kans.	.....	...	Ill ..	.....	.....	.....	.....	.....	.....	.....	.....	Otoe City, Brownville, Aspinwall.
64	*Aviculopecten occidentalis*, Shum	Kans.	Mo..	Io.	Ill¶	.....	.....	.....	.....	*	*	*	*	Otoe City, Brownville, Aspinwall.

[1] These plants were identified by Professor Lesquereux, who informs me that *N. Loschii*, although found in the Permian of Europe, ranges through the whole thickness of the Coal-Measures in Illinois; while *N. hirsuta*, which has been thought by some to be identical with a European Permian form, was first described by Prof. L. from the Coal-Measures of Pennsylvania, and he says it ranges throughout the whole area and thickness of the Illinois Coal-Measures. The fact that these two ferns occur at Morris, Ill., associated with a curious plant (*?*), thought to belong to a genus (*Palæoxyris*) only known in Europe in the Trias, might lead those unacquainted with all the facts to suspect that these Morris beds could scarcely be so old as the Carboniferous. It must not be forgotten, however, that these beds belong to the lower part of the Illinois Coal-Measures, and that we find there, directly associated with these plants, the well-known European Coal-Measure genus of *Crustacea*, *Anthracopalemon*, together with three other genera of *Crustacea* (*Palæocaris*, *Euproops*, and *Eurypterus?*) which, although not certainly identical generically, with European Carboniferous forms, are certainly far more nearly allied to the same than to anything yet known from the Permian. Such facts only show that several types of both animals and plants appeared at considerable earlier periods here than in Europe. This is even more strikingly the case in the Cretaceous flora of this country than in that of the Carboniferous, which fact led one of the highest European authorities on fossil botany, at first, to refer a collection of plant remains from our Cretaceous to the horizon of the Miocene.

[2] This species ranges down into the Chester and St. Louis limestones, of the Lower Carboniferous, in Illinois.

[3] A species of this genus occurs at Leavenworth City, Kansas, far down in the Coal-Measures, in a bed referred by Professor Swallow to the upper part of the middle Coal-Measures. Dr. White also finds it at about the middle of the Upper Coal-Measures in Iowa, and I have seen an imperfect specimen of the genus from the Lower Coal-Measures of West Virginia.

¶ This mark in the fourth column after the letters "Ill." indicates that the species is known not only in the *Upper*, but also in the *Lower*, beds of the Coal-Measures of Illinois. All of those from West Virginia were found in the Lower Coal-Measures.

Tabular list, illustrating the geological and geographical range of the fossils of Eastern Nebraska—Continued.

No.	Names of species.	COAL-MEASURES IN OTHER STATES.						ESPECIAL LOCALITIES IN NEBRASKA.						Miscellaneous localities in Nebraska.
		Kans.	Mo.	Io.	Ill.	Ky.	W. Va.	Omaha.	Bellevue.	Platts-mouth.	Rock Bluff.	Nebraska City, Wyoming, Bennett's Mill. B	Nebraska City, Wyoming, Bennett's Mill. C	
	ANIMAL REMAINS—Continued.													
65	*Aviculopecten neglectus*, Geinitz, (sp.)				Ill								*	
66	*Aviculopecten carboniferous*, Stv., (sp.)		Mo.	Io.	Ill¶		W. Va.						*	Morton's shaft, Nebraska City.
67	*Aviculopecten Whitei*, Meek			Io.	Ill¶							*	*	Morton's shaft; Brownville.
68	*Aviculopecten Coxanus*, M. and W				Ill¶								*	
69	*Aviculopinna Americana*, Meek			Io.									*	
70	*Pinna peracuta*, Shumard	Kans.	Mo.	Io.	Ill					*	*	*		
71	*Modiola ? subelliptica*, Meek	Kans.											*	
72	*Pleurophorus oblongus*, Meek				Ill¶								*	
73	*Pleurophorus occidentalis*, M. and H				Ill							*†		Otoe City.
74	*Edmondia ? reflexa*, Meek				Ill¶								*	Morton's shaft.
75	*Edmondia ? glabra*, Meek				Ill								*	
76	*Edmondia ? Nebrascensis*, Geinitz												*	
77	*Edmondia subtruncata*, Meek	Kans.									*			
78	*Edmondia Aspinwallensis*, Meek						W. Va.							Aspinwall.
79	*Solenomya*, sp				Ill¶								*	
80	*Solenomya*, sp									†	*			
81	*Prothyris elegans*, Meek				Ill¶								*	
82	*Chænomya Leavenworthensis*, M. and H	Kans.			Ill¶						*			
83	*Allorisma (Sedgwickia) reflexa*, Meek												*	
84	*Allorisma (Sedgwickia) Geinitzii*, Meek				Ill¶								*	
85	*Allorisma (Sedgwickia) subelegans*, M				Ill¶								*	
86	*Allorisma (Sedgwickia) granosa*, Shum	Kans.			Ill						*			
87	*Allorisma subcuneata*, M. and H	Kans.	Mo.	Io.	Ill¶				*	*	*	*		Brownville and Aspinwall.
88	*Solenopsis solenoides*, Geinitz, (sp.)				Ill¶						*		*	
89	*Dentalium Meekianum*, Geinitz				Ill¶								*	
90	*Bellerophon carbonarius*, Cox	Kans	Mo.	Io.	Ill¶	Ky.	W. Va.			*		*	*	
91	*Bellerophon Montfortianus*, N. and P	Kans.	Mo.	Io.	Ill¶		W. Va.						*	Morton's shaft.
92	*Bellerophon Marcouanus*, Geinitz				Ill¶								*	
93	*Bellerophon percarinatus*, Con	Kans	Mo.	Io.	Ill¶		W. Va.						*	Brownville.
94	*Bellerophon Kansasensis*, Swallow	Kans			Ill¶									Rulo.
95	*Euomphalus rugosus*, Hall	Kans.	Mo.	I.	Ill¶		W. Va.				*	*	*	Cedar Bluff, Aspinwall.
96	*Platyceras Nebrascensis*, Meek				Ill¶							*		Morton's shaft, Nebraska City; two miles below Bennett's Mill.
97	*Macrocheilus intercalaris*, M. and W				Ill							*		2¾ miles southwest of Nebraska City.
98	*Macrocheilus primogenius*, Con. ?			Io.	Ill¶		W. Va.		*					
99	*Orthonema subteniata*, Geinitz, (sp.)			Io.									*	
100	*Actis (?!) Swallowiana*, Geinitz, (sp.)				Ill ?								*	
101	*Pleurotomaria Haydeniana*, Geinitz												*	

102	*Pleurotomaria perhumerosa*, M.				Ill									Morton's shaft, Nebraska City; Rulo.
103	*Pleurotomaria sphærulata*, Con	Kans.	Mo.	Io	Ill¶	Ky.			*					
104	*Pleurotomaria inornata*, Meek				Ill¶									Morton's shaft, Nebraska City.
105	*Pleurotomaria Grayvillensis*, N. and P.	Kans.	?	Io	Ill¶	Ky.	W. Va.						*	
106	*Pleurotomaria Marconanus*, Geinitz												*	
107	*Pleurotomaria subdecussata*, Geinitz												*	
108	*Murchisonia Nebrascensis*, Geinitz												*	
109	*Orthoceras cribrosum*, Geinitz			?	Ill¶		W. Va.						*	
110	*Nautilus occidentalis*, Swallow	Kans.	Mo.		Ill¶		W. Va.				*		*	Aspinwall.
111	*Nautilus ponderosus*, White & St. John			Io	?									
112	*Cythere Nebrascensis*, Geinitz			Io									*	
113	*Phillipsia*, sp	?		Io							*		*	
114	*Phillipsia scitula*, M. and W				Ill¶							*		
115	*Phillipsia major*, Shumard	Kans			Ill¶						*			
116	*Deltodus ? angularis*, N. and W			Io	Ill									Do.
117	*Cladodus mortifer*, N. and W	Kans.			Ill						*	*		
118	*Petalodus destructor*, N. and W				Ill						*			
119	*Diplodus compressus*, N. and W				Ill						*			Rulo, Nebraska.
120	*Peripristis semicircularis*, N. & W., (sp.)				Ill			*	*					Morton's shaft.
121	*Chomatodus arcuatus*, St. John[1]											*		
122	*Xystrodus ? occidentalis*, St. John			Io									*	

[1] This species was found at Bennett's Mill, near Nebraska City, by Professor O. St. John.

The inseparable linking together of all of these Nebraska rocks under consideration, by their organic remains, as well as their identity with the Upper Coal-Measures of Iowa, Illinois, and other neighboring States, is so clearly exhibited in the foregoing list, as to render any extended comments upon these points almost unnecessary. Some concluding remarks, however, may assist in making these facts more manifest to those who may not have the time, or inclination, fully to analyze the list.

In the first place, it may be remarked, that as Professor Geinitz, the paleontological authority to whom Professor Marcou submitted his collection, now concedes that the Rock Bluff and Plattsmouth sections (which had been by the last-mentioned author referred to the Permian) really belong to the Carboniferous, the only questions that need be discussed here are, whether Professor Geinitz was right in referring the Plattsmouth beds to the Lower Carboniferous or Mountain limestone series, instead of to the Upper Coal-Measures, as he correctly referred the Rock Bluff section; and whether or not he and Professor Marcou are right in placing the Wyoming and Nebraska City outcrops on a parallel with the Permian or Dyas of Europe?

In regard to the first question, it is only necessary to repeat, that out of thirty-six species known from Plattsmouth, twenty-five (including millions of *Fusulina*), as may be seen by the list, also occur at Rock Bluff; while the remaining eleven Plattsmouth species not yet found at Rock Bluff, with one or two exceptions, may all (like the others) be seen to occur in the Upper and many of them in the Lower Coal-Measures of Illinois, Iowa, and other neighboring States. In addition to this, of all the species yet known from both of these localities, only some four or five (and these are forms, in this country, common to both the Coal-Measures and Lower Carboniferous) have ever been here found at any horizon below the Millstone grit. It is true, a larger proportion than this of these fossils agree in their affinities with European Lower Carboniferous forms; but the fact that the rocks in which they occur, in Kansas, shade without any defined physical or paleontological break, into the Permian above, *ought to be* convincing evidence that these Plattsmouth beds cannot be properly included in the Lower Carboniferous series.* This is also clearly shown by ther identity with the Upper Coal-Measure beds of Iowa and Illinois, which in the latter State, can be traced without interruption southward to where they and other still Lower Coal-Measure strata, containing, along with most of the same animal types, the remains of a well-marked Coal-Measure flora, rest directly upon extensive deposits, 300 or 400 feet in thickness, of Millstone grit; while beneath the latter, we have a great series of massive limestones and other strata, corresponding completely, not only in their physical characters and position, but also in the affinities of their entire group of fossils, with the Mountain limestone of Europe.

By a glance at the foregoing list, it will also be seen that the same reasoning applies, with equal force, against Professor Marcou's reference of the outcrops above the mouth of Platte River, at Bellevue and Omaha, to the Mountain limestone; since of the twenty-six species of fossils now known from these localities, twenty-four are the common forms of our Coal-Measures, while none of them, excepting a few that are well

* Since this was written, Dr. White, the able State geologist of Iowa, has, in his report, shown in the clearest manner possible, by sections across that State from the Mississippi River to the Missouri at Plattsmouth, that the rocks along the latter stream, at and near Plattsmouth, really belong to the Coal-Measures, and that there are no Lower Carboniferous rocks there within one thousand feet or more of the surface.

known to be common to the Coal-Measures and Lower Carboniferous rocks of the West, have ever been found below the horizon of the Mill-stone grit. Indeed, all but three or four of them (which are themselves well-known Coal-Measure species) also occur in the Plattsmouth beds, referred by Professor Marcou to the Lower Dyas. He has, it is true, made an effort to explain away this latter fact, on the ground that most of the fossils known to him from Omaha and Bellevue are *Brachiopoda*, which he thinks cannot be relied upon in the identification of strata, owing to their great vertical range. We now know, however, from these very beds at Bellevue, as may be seen by the foregoing list, the lamellibranchiate genera, and Coal-Measure species, *Myalina subquadrata*, and *Allorisma subcuneata*, both of which occur in the very beds referred by him elsewhere to the Upper Dyas. Again, we have the crustacean genus and Coal-Measure species, *Phillipsia major* of Shumard, both from these so-called Mountain limestone beds of Bellevue, and from the so-called Lower Dyas of Plattsmouth. Still further, we have from the Bellevue beds the well-known *vertebrate* Coal-Measure species, *Peripristis semicircularis*, which, strangely enough, supposing Professor Marcou correct, also occurs at Nebraska City and Bennett's Mill, in the so-called Upper Dyas, and at Rock Bluff, in the upper part of the so-called Lower Dyas (see Plates III and IV). So even if we admit that the testimony of the *Brachiopoda* may be, in some cases, less reliable than that of a few other types, we cannot ignore it when directly corroborated by that of the lamellibranchiates, trilobites, and fishes. I can, therefore, see no reason whatever for separating these beds from the Coal-Measures.

We come now to consider the propriety of Professors Marcou and Geinitz's reference of division B of the Nebraska City section, and at Wyoming and Bennett's Mill, to the Upper Dyas, or more properly to the Dyas at all. As shown in the list we know altogether from these beds about forty species of fossils, of which twenty, or one-half, are common to the same and the outcrops above Plattsmouth, referred by Professor Marcou to the Mountain limestone. Thirty of them also occur in the Plattsmouth and Rock Bluff strata, the first of which are placed by Professor Geinitz in the Lower Carboniferous, and the latter in the Upper Coal-Measures; while thirty-seven or thirty-eight, nearly the whole, consisting of *Fusulina*, polyzoa, corals, crinoids, brachiopods, lamellibranchiates, trilobites, and fishes, are found in the Upper, and, in part, the Lower Coal-Measures of Iowa, Illinois, and other neighboring States; and none of them, excepting a very few forms that are common to our Coal-Measures and Lower Carboniferous rocks, have ever been found in the latter in this country. Hence it seems to me clearly manifest that there is no reliable paleontological evidence for separating these beds from the Upper Coal-Measures. The only fact that gives the slightest show of reason for such a conclusion is the occurrence in them of the genera *Pseudomonotis* and *Synocladia*, with species resembling Permian forms of the genera *Schizodus*, *Pleurophorus*, *Nuculana*, &c., but it is exceedingly doubtful whether *any* of even these fossils are specifically identical with any known Permian form. The *Synocladia* is certainly not so, while it, and all the others, are well known to range far down into unquestionable Coal-Measures of the West, even below the horizon of the rocks referred by Professor Marcou to the Mountain limestone above Plattsmouth. For instance, a bed of limestone at near the level of the Missouri, at Leavenworth, Kansas, in which a *Pseudomonotis*, nearly allied to *P. speluncaria*, is known to occur, has been by Professor Swallow, who carries the line between the Upper Coal-Measures and Permian in that State several *hundred feet lower* than any others in this country,

these are, I acknowledge, *very* similar to the Permian species to which he has referred them, while the fifth seems to be as nearly like *Pleurophorus costatus*. To these we may perhaps also add the *Schizodus* represented by fig. 2, on plate X, which is very closely allied to *S. obscurus*, though more compressed. The fact, however, that we know comparatively little of the hinges and interior of these shells, while they are mainly such types as usually present few reliable external characters for specific distinction, and belong for the most part to genera in which species are frequently very similar, must weaken our confidence in these specific identifications, under such circumstances. But when we take into consideration the fact that precisely the same forms are found in the Western States far down in beds acknowledged by all to belong to the Coal-Measures, and which have even at some places been referred by Prof. Marcou to the Mountain limestone, and especially when we bear in mind, the numerous unquestionable Carboniferous species with which they are here directly associated in the beds under consideration, the impropriety of basing important conclusions upon them must be apparent.

I am not, however, wishing to conceal the fact that several of the *genera* found in these supposed Permian rocks, in Nebraska, and their equivalents in Iowa, Illinois, &c., are believed to be generally regarded as not in Europe dating back beyond the Permian epoch. But in considering these, we must not overlook the other genera equally characteristic of the Carboniferous, found in the very same rocks. The following lists include both types of genera:

A. CARBONIFEROUS GENERA.

1. *Fusulina*, 1 or 2 sp.
2. *Lophophyllum*, 1 sp.
3. *Campophyllum*, 1 sp.
4. *Eupachycrinus*, 1 sp.
5. *Erisocrinus*, 1 sp.
6. *Orthis*, 1 sp.
7. *Solenopsis*, 1 sp.
8. *Prothyris*, 1 sp.
9. *Phillipsia*, 2 sp.
10. *Petalodus*, 1 sp.
11. *Cladodus*, 1 or 2 sp.
12. *Peripristis*, 1 sp.
13. *Chomatodus*, 1 sp.
14. *Xystrodus*, 1 sp.
15. *Deltodus*, 1 sp.
16. *Antliodus*, 1 sp.

B. GENERA BELIEVED NOT TO DATE BACK OF THE PERMIAN IN EUROPE.

1. *Synocladia*, 1 sp.
2. *Aulosteges*,* 1 sp.
3. *Pseudomonotis*, 2 sp.
4. *Aviculopinna*, 1 sp.
5. *Bakerellia*, 1 sp.
6. *Placunopsis*,† 1 sp.
7. *Lima*, 1 sp.

It will thus be seen that while we have in the whole series of Upper Coal-Measures and Permo-carboniferous rocks of Kansas, Nebraska, Iowa and Illinois, seven genera, consisting of one of *Polyzoa* and five or six of true *Mollusca*, that have not, so far as known to the writer at this time, been found in Europe at any horizon below the Permian, and two of these, it is believed, not even that low in the series *there*, we find in the same horizon, and for the most part directly associated with these, sixteen other genera, consisting of one of *Foraminifera*, two of Corals, two of *Crinoidea*, three of *Mollusca*,‡ one of Trilobites, and seven of Fishes, not known to occur anywhere in more recent rocks than the Carboniferous. Seven of these, however, viz., *Erisocrinus*, *Eupachycrinus*, *Prothyris*, *Deltodus*, *Peripristis*, *Antliodus*, and *Xystrodus*, being new genera, it might be supposed ought not to be counted against the Permian. But it is worthy of note that even the typical species of

* Dr. White has discovered at about the horizon of the middle of the Rock Bluff section, in the Upper Coal-Measures of Iowa, attached to the coral *Campophyllum*, a minute Brachiopod, apparently possessing the characters of *Aulosteges*.

† A species presenting at least all the external characters of the genus *Placunopsis*, has been found in the Upper Coal-Measures of Illinois (see Proceed. Chicago Acad. Sci. 1, March, 1866, p. 13), and the same has since been discovered by the Geol. Survey of Ohio, in the Lower Coal-Measures of the latter State.

‡ The genus *Bellerophon*, of which we have four or five species in these rocks, has also, *I believe, not been found* in the Permian of Europe, though one species is known from *the Trias (St. Cassian* beds).

the genus *Erisocrinus*, occurs at Bellevue, in the very Coal-Measure beds erroneously referred, by Professor Marcou, to the Mountain limestone, as well as in the equivalent Upper Coal-Measure beds of Illinois. It is also certainly represented at far lower horizons by several lower Carboniferous species, two of which occur as low as the Burlington limestone; while the only other known species of *Eupachycrinus* is from the horizon of the Keokuk group. Again, the only other known species of the genus *Prothyris* was discovered by Professor Winchell in the very oldest member of the whole Carboniferous series in Michigan; and of the nine described species of *Antliodus*, and seven of *Deltodus*, all of the former, and all but one of the latter, are Lower Carboniferous forms, which is also the horizon of the only two known European species thought by Newberry and Worthen probably to belong to *Antliodus*. Again, the only known European species, believed by St. John to belong to the new genera *Peripristis* and *Xystrodus*, are Mountain limestone species, one of which is the type of the genus *Xystrodus*. The genus *Chomatodus* is likewise, I believe, essentially, if not exclusively, a Mountain limestone group in Europe. At any rate, of the ten described species of this country, nine are from the Lower Carboniferous, and only one (an Upper Coal-Measure species of Illinois) was found at any higher horizon. The genus *Petalodus* seems also to be nearly or quite confined to the Mountain limestone of Europe, though two or three species are known from the Upper Coal-Measures of Illinois, Kansas, Nebraska, and Pennsylvania. *Fusulina* is also, I believe, usually considered in Europe mainly, if not exclusively, a Lower Carboniferous genus, or at any rate one not ranging into the Permian.

On the other hand, of the six or seven genera mentioned in the foregoing list, that are supposed to be in Europe confined to the Permian and later rocks (none of which types, it will be observed, rank even among the higher lamellibranchiate *Mollusca*), the genus *Aviculopinna*, as may be seen by the figures and description, seems to be closely allied to Professor McCoy's Carboniferous and older genus *Pteronites*. Again, the genus *Bakevellia*, although most generally regarded in Western Europe as a Permian type, is said, by Eichwald, also to occur in the Carboniferous of Russia; and it seems, also, to be represented in Nova Scotia, according to high authority, at or below the base of the enormously developed Coal-Measures of that region. And almost certainly the very species of *Synocladia* alluded to, also occurs in the Chester and St. Louis limestones of our Lower Carboniferous series.

So it is evident that whether we look at the *species* or the *genera* found in the rocks under consideration, we see that there is an overwhelming weight of evidence against the conclusion that they represent the Permian of the Old World. Indeed, looking at the *genera* of animal remains alone, without regard to the plants or the position of these beds above the horizon of the Millstone grit and Mountain limestone, and by taking into consideration the greater weight due the evidence of such highly organized types as Trilobites and Fishes, it would not be difficult to bring forward a better argument in favor of the conclusion that this whole series belongs to the horizon of the European Mountain limestone, than that it represents the Permian. The mingling, however, of the few Permian types mentioned in the same beds with the numerous Carboniferous forms, already enumerated, through a considerable thickness of these and higher strata, together with the physical structure of our entire Carboniferous system, demonstrate, it seems to me, as clearly as facts can, that these rocks belong to the Coal-Measures, and that here *we have no abrupt break between* the Carboniferous and Permian.

REMARKS ON THE PROBABILITY OF FINDING VALUABLE BEDS OF COAL WITHIN PROFITABLE WORKING DISTANCE OF THE SURFACE IN EASTERN NEBRASKA.

It is well known that along the valley of Des Moines River, and some of its tributaries in Iowa, 75 to 100 miles east of the Missouri, extensive and valuable beds of coal exist. This coal is of good quality, in beds varying from a foot or so to 7 feet in thickness, and is regarded by Dr. White, the State Geologist, as belonging to the Lower Coal Measures. In going to Nebraska in the spring of 1867, I visited, with that gentleman, several localities where these Lower Coal-Measure rocks are seen, and as the facts observed there have a bearing on the coal question in Eastern Nebraska, a few remarks on these Des Moines Valley beds are necessary to a clear understanding of what will follow in regard to coal in Nebraska.

Dr. White had previously thoroughly explored this region and the country through from here to the Missouri, and knew all the localities where the best exposures are to be seen, and I am under great obligations to him for conducting me through from Iowa City to Nebraska City; and it is but just that I should state here, that all the facts observed by me, in the geology of Iowa, were previously known by him, and have been published in an interesting paper from his pen, in the American Journal of Sciences and Arts, vol. XLIV, 1867, and subsequently in his able report published by legislative authority.

The Lower and Middle Coal-Measures of the Des Moines Valley had also been, to a considerable extent, explored by Professor A. H. Worthen, when connected with a former survey of Iowa, and described at length in the report of that survey, published in 1858. They consist mainly of sandstones, shales, coal, and some thin, impure limestones, the maximum thickness of the whole, in this region, being supposed by Dr. White to be about 800 feet. They only come to the surface in the region of the Des Moines River, and northeast of there, excepting in some of the deeper valleys somewhat farther west, and are believed by Dr. White to include all the workable beds of coal in the State. Although in some places quite fossiliferous, they are generally not so much so here as the Upper Coal-Measures occupying all the country from near the Des Moines, westward to the Missouri.* As there is no Millstone grit here, the lower beds in this region rest directly down upon the Lower Carboniferous rocks.

The Upper Coal-Measures west of the Des Moines, as already shown by Dr. White, are not separable from the Middle series by any physical or abrupt paleontological break, a number of the species of fossil being common to both, and the whole having here a uniform and slight general dip to the west of south.

The last locality at which we saw any of the beds of the Middle series in going southwestward from the Des Moines Valley was near Winterset, Madison County, in the rather deep valley of Middle River, a tributary of the Des Moines. Here we saw only one of the very upper beds of the Middle series, in the bottom of the valley. This valley, like all the others in this region, is merely one of erosion, cut down to a depth of perhaps 250 feet below the common elevation of the country by the

* In some of the upper beds of the Middle series, however, we found *Spirifer cameratus*, Morton, *S. lineatus*, *S. planoconvexus*, Shumard, *Productus Nebrascensis*, Owen, *P. Longispinus*, Sowerby ?, *P. Punctatus*, Martin (*sp.*), *Hemipronites crassus*, M. & W., *Chonetes mesoloba*, N. & P., together with *Gerrilla longa*, Geinitz (a true *Aricula*), and *Ariculopecten carboniferus* Stevens (= *Pecten Hawni*, Geinitz).

stream now flowing in it. The hills on each side, to an elevation of about 220 feet, or perhaps more here, are composed of the succeeding higher series of the Coal-Measures, consisting of some comparatively heavy beds of light-yellowish limestones, with bluish, drab, and reddish clays, and sandy, micaceous shale, some black laminated shale, and a few inches of impure coal, the whole being overlaid by more or less heavy deposits of Drift.

In this Upper series of Coal-Measures, as already intimated, only separated as a matter of convenience, and not by any natural break from the Middle, we found the following fossils, nearly or quite all of which had been previously collected here by Dr. White: *Fusilina cylindrica*, *Rhombopora* and *fistulipora*, sp., *Eocidaris Halli*, *Hemipronites crassus*, *Meekella striatocostata*, *Productus costatus?*, *P. Nebrascensis*, *P. Longispinus*, *Spirifer cameratus*, *S. planoconvexus*, *S. lineatus*, *Spiriferina Kentuckensis*, *Chonetes Verneuiliana*, *Athyris subtilita*, *Terebratula bovidens*, *Retzia punctulifera*, *Macrodon tenuistriatus*, *Myalina perattenuata*, *M. subquadrata*, *Aviculopecten occidentalis*, *Bellerophon crassus*, and an undetermined *Phillipsia*. Dr. White also found in one of the upper limestones a tooth of a *Cochliodus*.

This, it will be seen, is, as far as it goes, with the exception of one or two species, almost precisely the same fauna characterizing the Upper Coal Measures along the Missouri, already so often mentioned, where the whole series, however, is much more developed, the entire thickness of the upper series here, near Winterset, being estimated by Dr. White as probably not exceeding 200 to 250 feet.

On ascending from this valley, we saw no more exposures of the Middle series, the southwestward inclination of the strata taking these beds beneath the bottoms of the deepest valleys. At various places, however, south of there, on Grand River, in Union County, and westward to the Missouri, somewhat above Nebraska City, the Upper series was seen more or less exposed, and readily recognized by the various fossils already mentioned. As these fossils, however, have nearly all a great vertical range in this Upper series, and beds at different horizons, especially in Kansas and Nebraska, where these rocks are greatly developed, are known to resemble each other very closely in lithological characters, it is not easy to be always sure of the *exact* horizon in the series, of particular beds seen at different localities. Dr. White, however, is quite confident that he can clearly identify the subordinate beds of most of the Winterset exposure, already mentioned, in the bluffs of the Missouri, on the Iowa side, twelve miles northeast of Nebraska City. Whether these beds are exactly equivalent or not with those at Winterset, there is not the slightest reason for doubting that they belong to the same Coal-Measure series, as do all the intervening exposures between these two localities.

On our arrival at Nebraska City, parties there interested in sinking a shaft, at Mr. Morton's farm, one and three-fourth miles west of the landing at that place, in search of coal, knowing that we had been examining the country across from the coal region of the Des Moines Valley to the Missouri, naturally wished to know how deep we thought they would probably have to penetrate to find coal. After taking into consideration the gentle dip of the strata from the outcrops of the Lower productive Coal series near the Des Moines, and the thickness of the Upper nearly or quite barren series at Winterset, Iowa, and making some allowance for the thickening of the latter in a westerly or southwesterly direction, of which we had seen some evidence, Dr. White and the writer *told the Hon. J. Sterling Morton* that we thought it possible

the productive series might be struck within about 500 feet of the surface of the Missouri Valley at Nebraska City. We apprised him, however, of the hazard and uncertainty generally attending such mining enterprises, and advised that before proceeding farther with the shaft (at that time carried to a depth of 80 or 90 feet) that they should first sink an artesian boring 600 to 800 or 1,000 feet if coal should not be sooner struck. We were not at that time, however, nor until on the eve of starting from Nebraska City for Omaha City, aware of the fact that a boring had already been sunk in the Missouri Valley, a short distance below Nebraska City, to a depth of about 344 feet without striking any workable bed of coal.

On taking this important fact, and others observed in the exposures seen between Nebraska City and Omaha City, into consideration, together with those developed by the borings at Omaha, we were led to the conclusion that it is exceedingly improbable that sufficiently thick beds of coal exist at Nebraska City within profitable working distance of the surface. As we came back from Omaha, a few weeks later, Dr. Hayden and I called to advise Mr. Morton to suspend work on the shaft, and, if he wished to make further exploration, first to sink Mr. Croxton's boring 500 or 600 feet deeper, if coal should not be sooner struck. Mr. Morton, however, was not at home, and we left the suggestions with his family. After my return to Washington I also wrote to him to the same effect.

Of course it is not within the scope of human wisdom to decide *positively* and *beyond doubt*, by any means short of actual boring, whether or not workable beds of coal could be struck there at depths that could be profitably wrought. The weight of evidence, however, from all the facts now known, is undoubtedly against success in such an undertaking. Some of the reasons for this conclusion are stated below.

In the first place, although some facts were observed indicating a slight northerly or northeasterly inclination of the strata on the north side of Platte River, there is little reason to doubt that the boring at Omaha City, about thirteen miles farther north, penetrates nearly, if not quite, the whole 400 feet, into lower strata than those forming the Plattsmouth section, where at low water about 60 feet of rocks can be examined inch by inch, and certainly contain no workable coal. From near this point there is evidently a gentle south or southeastward dip, so that at Rock Bluff, about six miles by a right line in a direction a little east of south from Plattsmouth, the upper part of the section at the latter place is brought so low as to leave little room to doubt that in these two sections we have an opportunity to examine in detail about 150 or 160 feet of strata (with the exception of a few feet at Rock Bluff, almost certainly occupied by sandstone) without finding any coal.

On going twelve miles farther down the river, in a nearly south direction, to Wyoming, we find the whole of the Rock Bluff section has, between these points, passed beneath the level of the Missouri, so that here at Wyoming we observe a low exposure, not agreeing with any part of the Rock Bluff section, but apparently occupying nearly the horizon of the lower part, or divisions A and B, of the Nebraska City section. It is possible, however, that there may be 40 or 50 feet of other unexposed strata between the top of the Rock Bluff section and the Wyoming outcrop. From these exposures and the borings at Nebraska City and Omaha City, we have pretty good data for the belief that there are no workable beds of coal beneath the Missouri level at Nebraska City for a depth of at *least* 600 or 800 feet. Consequently the Upper barren *measures almost* certainly thicken much more rapidly in coming south-

westward from Winterset, Iowa, than had been supposed. Dr. White's numerous local sections, however, observed at various points west and southwest of Winterset, through to the Missouri, seem to show very clearly that this thickening of the Upper series is not due to the deposition of newer strata upon the equivalents of those seen at Winterset, but to a thickening of the same beds seen there, or with probably, in part, to the intercalation of other similar strata between or beneath the lower members of the same.

At Nebraska City, and below there, at Otoe City, Brownville, and Aspinwall, there are, perhaps, altogether, near 150 to 200 feet of additional strata, holding probably all a position above the geological horizon of the top of the boring at Nebraska City. The various natural exposures, shallow shafts, drifts, and other excavations in these beds, show that they almost certainly contain no thicker bed of coal than the 22-inch bed seen at Aspinwall; so that these beds may, altogether or in part, also be added to the entire *explored* thickness of strata almost certainly without any seam of coal thicker than that cropping out at Aspinwall.

Somewhere below Aspinwall, a gentle dip of the strata to the north or northwest takes place, and causes lower beds to rise to the surface as we descend the Missouri from the southeast corner of the State. But, from what we saw near Rulo, it seems rather improbable that any beds come to the surface between that place and St. Joseph, in Missouri, belonging to much lower geological horizons than those penetrated by the borings at Nebraska City and Omaha, though it is possible some beds may exist there not represented under the latter places. At any rate, the observations of Mr. Broadhead, and those of Dr. Owen and Professor Swallow, along the Missouri, render it exceedingly improbable that any workable beds of coal exist in any of the strata holding a geological position between those seen at Rulo and the horizon of the top of the boring at St. Joseph, in Missouri. And as the boring at the latter place was carried to a depth of 480 feet, without striking a workable bed of coal, and no such beds crop out between there and Atchison, Kansas, while none such were struck in a boring at the latter place, extending to a depth of about 300 feet, the evidence becomes very strong that we have here a great series of nearly barren Upper measures, containing no beds of coal of more than about 2 feet in thickness.*

It is worthy of note in this connection, that Mr. Broadhead had arrived at the same conclusion in regard to the Coal-Measures of northwestern Missouri, from the examination of numerous natural exposures before any of these borings had been made. By examining a paper on the Coal-Measures of that region, published by him in the Proceedings of the St. Louis Academy of Sciences in 1865, it will be seen that he gives a continuous section of beds (with some unexposed spaces) of nearly 2,000 feet, before reaching a bed of coal as much as 2½ feet in thickness; all of those noted above being from a few inches to 2 feet in thickness. It is quite probable that all the numerous thin beds and seams of shale, clay, limestone, sandstone, &c., composing this long section, are not always here placed by him in their *exact* order of superposition, since it is generally impossible to see more than comparatively a few of them exposed in any one natural section, while it is very difficult, in a series of rocks like this, so liable to change their lithological characters in short distances, to be always right in identifying the same beds at different localities,

* Dr. White's observations in Iowa have also led him to the conclusion that the Upper and most *of the Middle Coal-Measures* of that State, contain no bed of coal of *more than two feet in thickness.*

especially as most of their fossils have a great vertical range. There is little room for doubting, however, that this section gives a good general approximation to the true structure of the series in that region. It evidently includes most, if not all, of the series referred by Professor Marcou and Professor Geinitz to the Dyas, Coal-Measures, and Mountain limestone; also the Upper and some of the Middle Coal-Measures, as well as probably some of the Lower Permian, of Professor Swallow's Kansas section.

There are a few leading facts that ought to be impressed upon the minds of those who may wish to seek coal in Eastern Nebraska. The first of these is, that the exposed rocks here belong to the upper, member of the great coal-bearing series, and that, although of considerable thickness, all observations and experience, not only here in Nebraska, but also in Kansas, Missouri, and Iowa, as already stated, render it almost a moral certainty that this Upper series, in this region, contains none but thin and unreliable beds of coal. Consequently if good workable beds exist here, it may be regarded as a nearly settled question that they lie *deep* beneath the level of the lowest valleys, in the Lower or Middle Coal-Measures; and if ever made available it must be by deep shafts. It would not be prudent, however, to attempt to reach these lower beds by directly sinking shafts; the proper course is first to demonstrate their existence here, and their depth, by artesian borings.

In making such borings here, they should, of course, commence in the deepest valleys. It ought also to be remembered, that it is simply throwing away money to make two or more such borings near each other, for in a country where the strata are so slightly inclined, and so free from faults as this, a single boring settles the question for or against the existence of coal, to the depth that it penetrates, for a considerable area of the surrounding country; since regular workable beds of coal are, with rare exceptions, not confined to one spot, but extend with the other strata for more or less considerable distances. Indeed, it is very probable that one boring at Omaha City, or six or eight miles up Platte River, where the rise of the strata would give a somewhat lower start, and another somewhere in the valley of the Great Nemaha, if carried to a depth of 1,200 to 2,000 feet, in case coal should not be sooner found, would, with the boring already made at Nebraska City, and the numerous natural exposures examined, settle the question in regard to the existence of workable beds of coal within accessible depths, in Eastern Nebraska.

Again, it ought to be generally known that money or labor expended in sinking shafts or excavating drifts into strata, every bed and seam of which may be examined in detail, and seen to be barren of coal in natural exposures in the immediate vicinity, will be certainly without reward. Much hard labor has also been squandered in Nebraska by excavating drifts into beds of black shale, with the delusive hope that if followed a hundred yards or so into a hill, they may be found to change into valuable beds of coal. Or, in thus following a 2 or 3-inch seam of coal, expecting it to be found much thicker farther in. Although such a result is not always certainly beyond the range of *possibilities*, it may be regarded as so nearly the case in these rocks as practically to amount to about the same thing. Indeed it may be almost taken for granted, from the numerous sections already examined inch by inch, and the facts developed by the borings, shafts, and other excavations already made, that no more valuable bed of coal than the 22-inch bed at Aspinwall, will ever be found here by such superficial openings.

In regard to finding workable beds of coal within accessible depths in Eastern Nebraska by deep borings, I would remark, in conclusion, that although not prepared to discourage entirely all hope of success, it is proper to state that all the known facts are unfavorable; not only on account of the great thickness of the Upper nearly barren series, but because it is by no means *certain* that we would strike the productive measures here, even after going entirely through the Upper nearly barren series, since the lower beds *may* thin out in this direction. The great importance, however, of a good supply of coal to a country so rich in other natural resources, and at present so scantily supplied with wood, certainly renders it desirable that some of the borings already commenced should be sunk to greater depths before abandoning all hope of success. That at Omaha City, for instance, which probably starts at a lower geological horizon than any other yet commenced in the State, should be at least continued on to a depth of 1,000 to 2,000 or more feet, in case coal should not be sooner found; for it is scarcely possible to estimate, at this time, at what depths it might be profitable, at some future time if not at present, by the aid of improved implements and skill, to mine coal here, directly on the great thoroughfare of trade and travel between the Atlantic and Pacific shores.*

* This report was prepared between three and four years back, and as I have not since visited Nebraska, I am at this time (April, 1871) unacquainted with any of the facts bearing on the question in relation to the probability of finding workable beds of coal there, that more recent borings or other explorations may have brought to light.

As some persons seem to be surprised that it should be thought possible to mine coal at the great depth of 2,000 feet, it may not be out of place to mention here, that coal is now being profitably raised in England from the enormous depth of 2,418 feet, while some of the best English mining engineers believe that within 20 years it will be there raised from shafts 3,000 feet in depth.

DESCRIPTIONS OF FOSSILS.

PROTOZOA.

FORAMINIFERA.

Genus FUSULINA, Fischer.

FUSULINA CYLINDRICA, Fischer.

Pl. I, Fig. 2; Pl. II, Fig. 1; Pl. V, Fig. 3, *a*, *b*; and Pl. VII, Fig. 8, *a*, *b*.

Fusulina cylindrica, Fischer, 1837, Oryct. Moscou, p. 126, Pl. 18, Figs. 1–5; Murch. de Vern. and Keys., 1845, Geol. Russ., 11, p. 16, Pl. 1, Fig. 1, *a*, *b*, *c*, *d*, *e*; Owen, 1852, Geol. Survey Wisconsin, Iowa, and Minn., p. 131, &c.; Meek & Hayden, 1859, Proceed. Acad. Nat. Sci., Philadelphia, p. 24; Dana, 1863, Man. Geol., p. 164, Fig. 193; Meek & Hayden, 1864, Paleont. Up. Mo., p. 14. Pl. 1, Fig 6, *a*, *b*, *c*, &c.; Meek, 1864, Paleont. California I, Part I, p. 4, Pl. 2, Fig. 1; Geinitz, 1866, Carb. und Dyas in Neb., p. 71, Tab. V, Fig. 5.

Shell small, fusiform or sub-cylindrical, more or less ventricose in the middle, somewhat obtusely pointed at the extremities, which generally have the appearance of being a little twisted. Surface smooth, excepting the septal furrows, which are moderately distinct, more or less regular, and a little curved as they approach the extremities. Aperture apparently linear, and not visible as the specimens are generally found. Volutions 6 to 8, closely coiled, the spaces (near the middle) being rarely more than twice the thickness of the shell walls. Septa from 20 to about 33 in the last or outer turn of adult specimens, counting around the middle; comparatively straight near the outer walls, but strongly undulated laterally within; foramina passing through the walls, moderately distinct in well-preserved specimens—as seen under a high magnifying power, in transverse sections near the middle of the shell, somewhat radiating, and numbering in the outer turn of a medium-sized specimen, from 12 to 20 between each two of the septa.

Varying considerably in size and form; length or greater diameter of medium-sized individuals, 0.27 inch; thickness, or shorter diameter, 0.08 inch.

In following the general practice of referring this to the Russian species, I am not only governed by comparisons with figures and descriptions of the latter, but I have had an opportunity to make direct comparison with specimens of *F. cylindrica* kindly sent to me by Colonel Romanowski, of the Russian mining-engineers's department, from the Ural Mountains. It is true these Russian specimens are not in a condition to show very clearly in polished sections the minute details of their internal structure under the microscope, but so far as I have been able to determine from the comparison, they seem to agree well with the American form.*

I have never yet seen any specimens presenting the form of that figured by Professor Geinitz under Fischer's name, *F. compressa*. If this compressed bicarinate appearance is not due to accidental pressure, I should think it a distinct species; though the specimens of these little foraminiferous shells have often been subjected to various accidents,

* I was interested to find among the Russian specimens sent by Colonel Romanowski, the globose species of *Fusulina* described by me in the California report, from the Carboniferous rocks of that State, under the name *F. robusta*, with which the Russian *authorities had* correctly identified it.

and besides they vary so much naturally, that the separation of the species is generally attended with great difficulty.

Locality and position.—One of the specimens figured is from a locality two and a half miles west of Nebraska City; it also occurs at Bennett's Mill, Wyoming, &c., all in beds referred by Professor Marcou and Professor Geinitz to division B of the lower part of their Upper Dyas: likewise at a higher position one mile southeast of (or below) Nebraska City, and at lower positions in the Coal-Measure on the Missouri, at Rock Bluff, Plattsmouth, Bellevue, Omaha City, &c. In short, it ranges all through the Coal-Measures, and is widely distributed in the Western States and Territories.

RADIATA.

POLYPI.

Genus RHOMBOPORA, Meek.

Small ramose corals, with non-septate, short tubular cells, radiating obliquely outward and upward on all sides from an imaginary axis; cell-mouths rhombic or rhombic-oval, and very regularly arranged in longitudinal and oblique spiral rows, the former of which are sometimes separated by more or less flexuous longitudinal ridges; interspaces usually rather thick, and not pierced by transverse pores, but occupied by very minute non-septate longitudinal cells that are closed and represented at the surface by minute granules or spinules.

Type, *Rhombopora lepidodendroides*, Meek.

The little corals composing this group are closely allied to some of those included by Professor Hall in his genus *Trematopora*, if not really congeneric with a part of the same. They differ, however, from the typical species of that group, such as *T. tuberculosa*, in not having the interspaces between the cells septate, but occupied by very minute tubes or pores (closed at the surface), as well as in the rhombic form, and very regular arrangement of the cell-mouths. *Trematopora aspera*, Hall, has much the external aspect of our genus, excepting in its elongate oval instead of rhombic cell-mouths.

Millepora rhombifera, Phillips, *Vincularia ornata*, Eichwald, and *Fasosites serialis*, Portlock, may, with much confidence, be included in this genus. The species of this group with which I am acquainted are from the Carboniferous rocks, through the whole of which the genus ranges, and I suspect that it is also represented in the Devonian and Silurian. None of the species I have yet seen seem to be incrusting or have hollow tubular stems, but there may be such among the undescribed species. Although some species of this genus have been referred to Goldfuss' genus *Vincularia*, they are widely removed from the typical Cretaceous species of that genus.

RHOMBOPORA LEPIDODENDROIDES, Meek,

Pl. VII, Fig. 2, *a*, *b*, *c*, *d*, *e*, *f*.

Stenopora columnaris (*pars*), Geinitz, 1866, Carb. und Dyas in Neb., p. 66; (not Schloth. 1813).

Ramose, slender, cylindrical or slightly compressed, and bifurcating at regular, distant intervals; divisions nearly straight between the points of bifurcation, *where they diverge at angles* of about 70° to 80°; com-

posed of small, short, nearly round, tapering tubes, that ascend from an imaginary axis, obliquely outward, with more or less curve to the surface, near which they are separated by interspaces, which in cross-sections show the minute cellular structure; calices arranged very regularly in quincunx, so as to form vertical and oblique rows; distinctly rhombic at the surface, where their margins are roughened by small, prominent, node-like grains, placed one at each corner, with smaller granules along the edges between.

Entire size unknown; thickness of one of the largest branches, 0.07 inch; length between bifurcations, 0.40 inch; number of calices in 0.20 inch, measuring longitudinally, 12; number of calices in 0.05 inch, measuring in the direction of the oblique rows, 4.

The rhombic form of the cell-mouths, and their very regular arrangement, are often well marked in this species. These characters, however, and the granules along their margins, are only to be seen in well-preserved specimens, for when slightly worn the granules are removed, and the angular character of the calices becomes nearly obsolete. When the surface is ground a little obliquely, the calices present an oval outline, as seen in Fig. 2 *e*, of Plate VII, while the thin interspaces present a cellular structure, as if occupied by minute vertical cells; one of these cells is larger than the others between the ends of the calices and seems to correspond to the larger grainlike node between the ends of each two of the calices. In longitudinal sections I have been entirely unable to detect transverse plates in the calices or interspaces. In old specimens the cell-walls seem to have become proportionally thicker and the cells consequently smaller.

As this is the only little coral we found in division C, at Nebraska City, among extensive collections, I am led to think it must be one of those referred by Professor Geinitz to *Stenopora columnaris* of Schlotheim. However that may be, I have no doubt, after a careful comparison with ramose specimens sent under the latter name from Posneck, Thuringia, that the Nebraska fossil is clearly distinct. In the first place, it differs in the regular rhombic form of the apertures of its well-preserved calices, and in the uniform arrangement of a larger granule at each of their corners, and one or more rows of very minute ones along each margin between. The specimens of *S. columnaris* mentioned above, have granulated margins to the calices; but these grains are irregularly arranged, while the calices themselves never present the rhombic outline seen in our fossil, but are always oval at the surface.

In division B, at Nebraska City, the coral under consideration is often almost completely covered by the following described incrusting species. As Professor Geinitz includes under the one species *Stenopora columnaris* both incrusting and ramose forms, it is probable he included this as one of the varieties of that species. But Edwards and Haime consider the species *columnaris* as peculiarly an incrusting coral. At any rate, the species here described differs so materially from that incrusting it, that the two can be distinguished almost at a glance by external characters alone, while internally, also, they seem to me to present structural differences of generic importance. These differences are so readily seen in the figures as to render any detailed comparisons unnecessary.

Locality and position.—Division C, of Nebraska City section; also in division B of the same at that place, where, as above stated, it is generally incrusted with another coral. It likewise occurs in the latter horizon at Bennett's Mill, Wyoming, &c., and at lower horizons in the Upper Coal-Measures at Rock Bluff, and Plattsmouth, as well as at various

itions in the Upper Coal-Measures of Nebraska, Kansas, Iowa, Mis-ri, and Illinois.

Genus FISTULIPORA, McCoy.

FISTULIPORA NODULIFERA, Meek.

Pl. V, Fig. 5, *a*, *b*, *c*, *d*.

ora columnaris Geinitz, 1866, Carbonf. und Dyas in Nebraska, p. 83; (not *S. columnaris*, Schoth., sp.

rallum incrusting crinoid columns, small branching corals, and r objects, so as often to assume cylindrical, irregular, or false ramose s; surface more or less nodulous, but without granules or spinules; nouths circular, small, or generally less than 0.01 inch in diameter, when not worn, with prominent smooth margins, generally directed tle obliquely outward from the centers of the prominences on the r; interspaces usually slightly less than or about equal to the diam- of the cell-mouths, but sometimes (particularly on the prominences) r; composed of from one to three ranges of minute vesicles, usually le wider than high, and separated by very thin diaphragms; dia-gms of principal cells not seen.

is coral is quite common through most of the Coal-Measures of the t. It often incrusts crinoid columns, and, wherever associated with nore delicate little coral for which I have proposed the name *Rhombo-lepidodendroides*, it incrusts the slender stems and branches of that ies so completely as entirely to conceal the latter, and thus to ap- as if it were itself ramose. Transverse or longitudinal sections, how-, reveal the little stems, with an entirely different structure within. ve seen no examples of it ramose, however, where not thus modi- by the very distinct coral upon which it so often grows.

an scarcely doubt that this is one of the species referred to *Steno-columnaris* by Professor Geinitz, as it is common in the same beds, at the same localities from which he cites that species, some of the s of which it nearly resembles in general appearance, as well as in ode of growth. I cannot believe, however, that it is nearly allied at species, because it shows no traces whatever, on perfectly pre-d specimens, of the granules or spinules of the interspaces, char-izing the forms included by Professor Geinitz in Schlotheim's spe- where well preserved. On the contrary, it seems to me to have structure of *Fistulipora* of McCoy; while the European forms red by Professor Geinitz to the species *columnaris* are thought to g, in part at least, to the genus *Labechia*, by Edwards and Haime. nong the described species of *Fistulipora*, this coral seems to agree nearly, in the size of its cell-tubes and the structure of its interme- vesicular tissue, with *F. minor* of McCoy. Still its cell-mouths are ler and more closely arranged, there being from six to seven in the e of one line, while in Professor McCoy's species, four occupy the space. It also never appears to grow to the thickness of that es, and consequently has much shorter tubes. The nodes or prom-es of its surface are comparatively large, like those seen on *Monti-ora*, d'Orbigney, and on these the cell-mouths are most widely sep-d, and usually directed slightly outward from the middle of each in which case the upper margin or lip of each cell is slightly more inent than the other.

I do not know that this nodose character has been observed in the genus *Fistulipora*, and hence the coral under consideration would seem to differ from the typical species of that genus about as *Monticulipora* differs from *Chætetes*. These nodes, however, are not always developed, and seem to have no regular arrangement. Sometimes they seem to be merely represented by slightly more scattering spaces of cell-mouths, without any elevation.

Locality and position.—Nebraska City, Bennet's Mill, and Wyoming, from bed B of the Nebraska City section. It also occurs at various other localities and positions in the Coal-Measures of Nebraska, Iowa, Illinois, and other Western States.

Genus SYRINGOPORA, Goldfuss.

SYRINGOPORA MULTATTENUATA, McChesney.

Pl. 1, Fig. 5 *a*, *b*, *c*, *d*.

Syringopora multattenuata, McChesney, 1860, Descriptions New Paleozoic Fossils, p. 75; also 1865, Pl. 2, Fig. 4, *a*, *b*, illustrations of same.

Corallum forming large masses; corallites cylindrical, long, slender, flexuous, more or less radiating, varying in their distance apart from once or twice their own breadth to close contact; connecting tubes numerous, slender, transverse, irregularly distant, but generally rather close; epitheca thick and rather strongly wrinkled. Septa unknown; tabulæ very obliquely and irregularly arranged.

Size of corallum unknown, but fragments indicate a diameter of 5 to 7 inches. The diameters of the corallites are quite uniform, and about 0.07 to 0.08 inch. They are rarely more than twice their own diameter apart, and often so closely compacted together as to become more or less angular, in which cases the connecting tubes are of course obsolete, but connecting openings take their places. In these compact examples, when the corallum is broken parallel to the corallites, these little transverse openings give it almost the appearance of a *Favosites*. This species seems to be related to *S. geniculata*, Phillips, but differs in having the corallites often closely compacted, and perhaps generally slightly smaller.

Locality and position.—Four miles up Platte River, north side, in the Upper Coal-Measures; it is also common at the same horizon in Illinois, eight miles south of Springfield.

Genus LOPHOPHYLLUM, Edwards & Haime.

LOPHOPHYLLUM PROLIFERUM, McChesney, (sp).

Pl. V, Fig. 4 *a*, *b*.

Cyathaxonia prolifera, McChesney, 1860, Descr. New Pal. Foss., p. 75; also 1865, Fig. 1. Pl. 2, illustrations same.

Cyathaxonia, sp. Geinitz, 1866, Carb. und Dyas in Neb., pp. 65 and 66, Tab. V, Figs. 3 and 4. Comp. *C. tortuosa*, Michelin, 1846, Icon. Zooph., p. 258, Pl. 59, Fig. 8.

Corallum elongate-conical, more or less curved, or sometimes nearly straight, tapering to a pointed base; epitheca very thin, with more or less distinct encircling wrinkles and striæ of growth, crossed by longitudinal striæ; rarely sending off a few spines near the base. Calice nearly or quite circular, moderately deep; columella prominent, compact in texture, compressed above, with its longer axis coincident with the general curve of the corallum; septa from about 30 to 50, every alternate one generally considerably shorter than the others, which latter extend to the columella, near which they are sometimes a little tortuous.

The largest of the specimens from which the foregoing description was drawn up is about 0.82 inch in length, and 0.42 inch in breadth at the larger end; the species, however, sometimes attains quite double this length.

I have not seen specimens of this species showing the septal fossula very clearly. Those from Nebraska are generally broken and distorted, but on comparison with examples from the Coal-Measures of Illinois, they are found to agree well in all their known characters. By examining longitudinal sections, I have ascertained that there are in this coral rather distant tabulæ or plates, extending outward with a strong downward curve from the columella, and hence that it does not even belong to the family *Cyathaxonidæ*, but seems to agree well with *Lophophyllum*.

Professor Geinitz compares this species to *Cyathaxonia tortuosa* of Michelin, from the Carboniferous rocks of Tournay, to which it seems to be very similar in external characters; but if that species is a *Cyathaxonia*, of course the form under consideration must be widely different.

Locality and position.—The specimens described are from division B of the Nebraska City section. Professor Geinitz also figures it from division C of the same section, and it occurs at Rock Bluff, Nebraska; and at Springfield, Lasalle, and numerous other localities in the Coal-Measures of Illinois, as well as in the adjoining States, and Texas.

Genus CAMPOPHYLLUM, Edwards & Haime.

CAMPOPHYLLUM TORQUIUM, Owen, sp.

Pl. 1, Fig. 1, *a*, *b*, *c*, *d*.

Cyathophyllum vermiculare?, Owen, 1852, Report Geol. Survey Wisconsin, Iowa, and Minnesota, p. 133, Pl. IV, Fig. 2; (not Goldfuss, 1826).
——— *flexuosum?*, Owen, 1852, ib., Fig. 3, *a*, *b*; (not C. (*Madrepora*) *flexuosum*, Linn., 1767, nor Goldfuss, 1826).
——— *torquium*, Owen, 1852, ib., explan. Pl. IV, Fig. 2.

Corallum simple, attaining a rather large size, elongate-conical, and often variously geniculated or bent when two or three inches in length, but becoming nearly straight, subcylindrical, and considerably elongated in the larger half of adult individuals. Epitheca thin, with small encircling wrinkles and strong undulations of growth, showing no traces of septal costæ when unabraded, but, where even slightly worn, exposing the regularly disposed septa, and thin intervening dissepiments distinctly. Calice circular or slightly oval, comparatively shallow, with thin margins, from which its sides slope rather steeply inward for some distance, and then descend very abruptly into a deeper, narrow, central depression; provided at the outer side of the general curve of the corallum with a moderately distinct septal fossula, formed by the shortening of one of the primary septa, and the bending down of the tabulæ at that point. Principal septa from 30 to 48, extending from about one-half to two-thirds of the distance from the exterior toward the center, stout and usually nearly straight inside of the vesicular outer zone, but becoming distinctly more attenuated (as seen in transverse sections) and somewhat curved or a little flexuous in crossing the vesicular area, where they alternate with an equal number of very short, thin ones; tabulæ very wide or occupying about two-thirds of the entire breadth, as seen in longitudinal sections, and passing nearly horizontally across, with a more or less upward arching; dissepiments thin and forming numerous obliquely ascending, small vesicles, in transverse sections seen to pass across between the costæ with an outward curve.

Entire length unknown, but individuals incomplete at both extremities, 5 inches in length and 1.60 inches in breadth, have been met with. These were probably not less than 7 or 8 inches in length when entire. Individuals of this size show at the thickest part 9 costæ in a space of 0.50 inch.

Young tortuous individuals of this coral were referred by Dr. Owen with doubt to *Cyathophyllum tortuosum*, Goldfuss, and large straighter fragments of adult specimens, from the same beds, were doubtfully referred by him to *C. vermiculare* of Goldfuss. After a careful examination, however, of a large number of specimens, I am led to the conclusion that they have the same internal structure, and really belong to one species. Although the large straighter specimens resemble quite nearly in their general appearance Goldfuss' figure of *C. vermiculare*, they are found to differ widely in their internal structure, *C. vermiculare* having from 64 to 100 septa, the larger of which extend in to the center. In the same way the smaller flexuous specimens resemble *C. flexuosum* of Goldfuss, with which they agree, more nearly in internal structure. They differ, however, in having the tabulæ much more closely crowded, and arching upward, or, in other words, curved downward on each side, as seen in longitudinal sections.

In some respects our coral seems nearly related to *Caninia sub-ibicina* of McCoy (as illustrated in his Brit. Pal. Foss., Pl. 3 I, Figs. 35, 35 *a*), but it has not near so many septa, that species having as many as about 130 in the two series.

Locality and position.—Very abundant in beds 11 and 12 of the Rock-bluff section; also common at about the same horizon at Cedar Bluff. Dr. White likewise finds it near this horizon in the Coal-Measures of Iowa; and it also occurs in the Coal-Measures of Illinois.

ECHINODERMATA.

Genus ERISOCRINUS, Meek & Worthen.

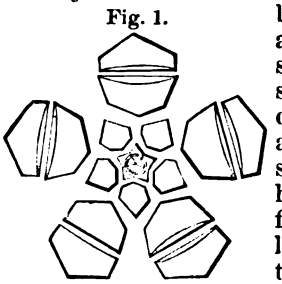
ERISOCRINUS TYPUS, M. & W.

Pl. 1, Fig. 3, *a*, *b*.

Erisocrinus typus, Meek & Worthen, 1865, Am. Jour. Sci., Vol. XXIX, p. 174; also 1866, Geol. Rep. Ill., Vol. II. p. 317, Fig. 33.
Philocrinus pelvis, Meek & Worthen, 1865, Am. Jour. Sci., Vol. XXIX, p. 350.
Erisocrinus Nebrascensis, Meek & Worthen, March, 1865, ib., p. 174.

Body below the summit of the first radials, basin-shaped, rounded below, and obscurely subpentagonal in outline as seen from above or below; composed of thick, smooth, slightly convex plates. Basal pieces small, occupying a shallow concavity of the under side, about half hidden by the column, all pentagonal in external form. Subradial pieces considerably larger than the basal, and all equally hexagonal in form. First radial pieces four or five times as large as the subradials, wider than long, equal, and all pentagonal; supporting upon their broadly and evenly truncated superior sides the second primary radials, which are of nearly the same size and form as the first, but have their sloping sides above instead of below, while they each support above, two first brachials, or a series of secondary radials yet unknown. Surface smooth.

Fig. 1.



Erisocrinus typus.—Showing the structure of the body from the base to the second radials inclusive. (From Illinois State Geological Report.)

Breadth of body below the summit of the first primary radials, 0.72 inch; height of same, 0.35 inch.

From the slightly larger proportional size of the subradial pieces, I was at one time led to believe this specifically distinct from the Illinois specimens upon which the genus and species *E. typus* were founded. Further comparisons of additional specimens from the original locality near Springfield, however, showed clearly that no separation could be made on this character.

When Professor Marcou announced, some time back, that he had found a crinoid at Nebraska City, nearly related to *Encrinus*, I very naturally supposed he alluded to the form here under consideration, knowing it to be not unfrequently met with in these rocks in Nebraska, as well as in Illinois; while its body, below the summit of the first radial pieces, has almost exactly the structure of the corresponding parts of *Encrinus*, excepting that it has a well-developed series of basal pieces within the series usually regarded as basals in *Encrinus*.* It was not until the publication of Professor Geinitz's memoir, in which the form alluded to by Professor Marcou was figured, that I was aware the species mentioned by him is one more widely removed from *Encrinus*, by having a large, well-developed anal piece resting down upon one of the first subradials, a character modifying the whole structure of the parts of the body above.

The form mentioned by Professor Marcou, and figured by Professor Geinitz (*Poteriocrinus hemisphæricus*, Shumard), *Zeacrinus mucrospinus*, McChesney, and that here under consideration, as well as perhaps several others only known by fragments, are all more or less nearly related. Indeed, the separate first primary radials, and, perhaps, some of the other parts of these crinoids, when found disconnected, can scarcely, if at all, be distinguished specifically. The truncated subradial, however, on the anal side of *Poteriocrinus hemisphæricus* (not a true *Poteriocrinus*) can always be distinguished from any of the parts of the other forms mentioned; while the curiously developed spine-like second radials of *Zeacrinus mucrospinus* can always be readily recognized.

All of these crinoids are peculiar to the Coal-Measures of the West, where they are widely distributed.

Locality and position.—The specimen figured on Pl. 1, was found by Dr. Hayden, eight or nine years since, at Bellevue, Nebraska. The species was first described from the Upper Coal-Measures at Springfield, Illinois. We also have fragments of apparently this crinoid from division B, at Nebraska City.

Genus SCAPHIOCRINUS, Hall.

SCAPHIOCRINUS? HEMISPHÆRICUS, Shumard, sp.

Pl. V, Fig. 1, *a*, *b*; and Pl. VII, Fig. 1, *a*, *b*, *c*.

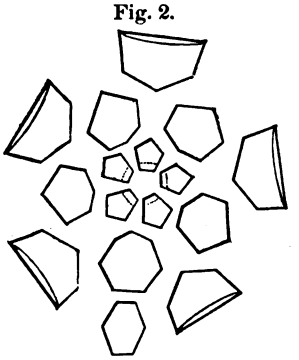
Poteriocrinus hemisphæricus, Shumard, 1858, Trans. St. Louis Acad. Sci. 1, p. 221.
Cyathocrinus inflexus, Geinitz, 1866, Carb. und Dyas in Neb., p. 62, Tab. IV, Fig. 20, *a*, *b*, *c*, and Fig. 28, *a*, *b*, *c*.

Body below the summit of the first radials sub-hemispherical, with the

* I mentioned in 1865 (Am. Jour. Sci., XXIX, 174), seeing a series of minute rudimentary pieces in a true *Encrinus*, belonging to Smithson's private collection at the Smithsonian Institution, within the range usually regarded as basals. As these, however, are not so developed as to be seen externally, and assume the character of true basals, and our crinoid seems to differ in the structure of its superior parts, it cannot be properly referred to that genus, though evidently closely allied to it.

under side deeply concave. Base very small, pushed or inverted entirely within the cavity of the body, and nearly or quite hidden externally; column facet round and deeply sunken. Sub-radial pieces of moderate size, very nearly equal, having a general pentagonal form, excepting the one on the anal side, which is a little truncated above by the anal piece, so as to give it a general hexagonal outline; each, however, has an additional very obscure mesial angle at its connection with the base, and all are strongly incurved below, to form the concavity of the under side. First radial pieces nearly twice as large as the sub-radials, twice as wide as high, and equally pentagonal, the upper sides being longer than either of the others, and all evenly truncated. Second primary radials (at least the two on the anal side) comparatively narrow, but still wider at the base than high, rounded on the outer side, a little constricted in the middle, and pentagonal in form, the two upper sloping sides supporting the first divisions of the arms, which are composed, at least for the first three ranges, each of a single series of wedge-formed pieces. First anal piece comparatively small, a little concave, resting upon one of the sub-radials, and connecting with the first radial on each side, above which it projects; supporting upon its slightly incurved upper edge a second piece, the form of which is unknown. Surface smooth, or only with traces of minute granules.

Fig. 2.



Scaphiocrinus? hemisphæricus.—Diagram showing the structure of the body from the base to the first radial pieces, inclusive.

The specimen from which the above description was made out is 0.66 inch wide, and 0.27 inch high to the summit of the first radial pieces.

In this, as in the several known species of *Erisocrinus*, and some other allied forms of the Coal-Measures, the first radial pieces are very thick on the upper edge, which has a neatly crenated ridge, with a furrow on each side of it, along the outer margin. These first primary radial pieces have exactly the form of the corresponding parts in *Erisocrinus*, and, as we have reason to believe, of one or more undefined genera of these rocks, and when found detached cannot be distinguished. The sub-radial piece, however, on the anal side of this crinoid, can at once be distinguished from any of those of *Erisocrinus* by the truncation of its upper side (see Fig. 28, *a*, *b*, *c*, Tab. IV, of Geinitz's Carb. und Dyas). On the inside of the cup of this and the allied forms alluded to, the sunken basal pieces are seen to rise so as to form a kind of pyramidal or conical protuberance.

Until the vault of these crinoids is known it will be difficult to determine whether they are more nearly allied to *Poteriocrinus* or to *Cyathocrinus*. From all analogy, however, I am led to think they will be found to possess the large prolonged trunk or proboscis of the *Poteriocrinus* group, instead of the merely vaulted summit and lateral tube of *Cyathocrinus*.

When we compare the structure of this crinoid, as far as yet known, with that of *Scaphiocrinus simplex*, Hall, the type of that group, it will be seen to agree in all respects, aside from mere specific characters, such as its concave under side, slight difference of form, &c., though it differs more widely from several of the other species that have been referred to that group, in having but a single anal piece, composing a part of the walls of the cup. Hence I have been led to place it provisionally in the

Scaphiocrinus group, generally regarded as a sub-genus under *Poteriocrinus*. It is worthy of note, however, that it is still a matter of doubt whether *Scaphiocrinus* will not be found a synonym of *Graphiocrinus*, de Kon., when it is known whether or not that type has minute basal pieces within those supposed to be such.

Locality and position.—Professor Geinitz figures a fine example of this species from division C of the Nebraska City section; and we have it from Bennett's mill, included by him and Professor Marcou in division B of the Upper Dyas. We also have it from Omaha, &c., from a lower position in the Coal-Measures referred by them to the Lower Carboniferous. It also occurs in the Coal-Measures of Iowa, Kansas, Illinois, &c.

Genus ZEACRINUS, Troost.

ZEACRINUS ? MUCROSPINUS, McChesney

Pl. V, Fig. 2 *a*, *b*, *c*.

Zeacrinus mucrospinus, McChesney, 1860, New Paleozoic Foss., p. 10; also, 1865, illustrations of same, Pl. 4, Fig. 7, *a*, *b*.
Actinocrinus, sp., Geinitz, 1866, Carb. und Dyas, Tab. IV, Fig. 29, *a*, *b*; (not *Actinocrinites*, Miller, 1821).

As pointed out by me some time back (Am. Jour. Sci., Vol. XLIV, new series, p. 176), the spines figured in Professor Geinitz's work, cited above, are those of a type belonging to the same family as *Poteriocrinus*. This curious crinoid has a cup almost exactly of the same form as the last, being sub-hemispheral, rounded below, and provided with a very small deeply sunken base, almost entirely hidden by the column. Its anal series of plates, however, is different from that of the last, these pieces being here more numerous and arranged as in *Zeacrinus*. Its most remarkable peculiarity, however, consists in having its second primary radial pieces produced outward into long spines. These spines Professor G. mistook for those of some species of the *Actinocrinites* group, like *A. Gouldi* of Hall. The spines of the latter, however, belong to an entirely different part of the crinoid, being modified vault-pieces, and hence have the head, or larger end, of a very different form. Consequently those under consideration can be distinguished at a glance from the spines of any of the species allied to *Actinocrinites*. In addition to this, the two types occupy distinct geological horizons, no *Actinocrinoid* being known in this country as high in the series as the Coal-Measures.

I have reproduced on Plate V, Professor Geinitz's figures of these spines, because we found no good specimens of them from any of the localities near Nebraska City. For comparison I have also given a copy of Professor McChesney's figure of one of these pieces of his typical specimen. That figured by Professor Geinitz, however, has the larger end somewhat obscured by adhering foreign matter, or from wearing so as partly to obliterate the markings on the upper side (Fig. 2 *a*) supporting the two first divisions of the arms.

Locality and position.—Professor Geinitz figures the spines of this species from Bennett's Mill, three miles northwest of Nebraska City, from beds referred by him and Professor Marcou to the lower part (division B) of their Upper Dyas. We have them from Plattsmouth, Cedar Bluff, Omaha, and numerous other localities and positions in the Coal-Measures of Nebraska and Kansas. They likewise occur in the same horizon in Iowa, Illinois, Missouri, Arkansas, &c. But they never, so far as known, occur at any horizon below the Coal-Measures; though Professor Worthen and the writer have described an allied representative species from *the Chester Limestone* of the Illinois Lower Carbonifer-

ous series. No analogous crinoid has ever been described in Europe from the Permian.

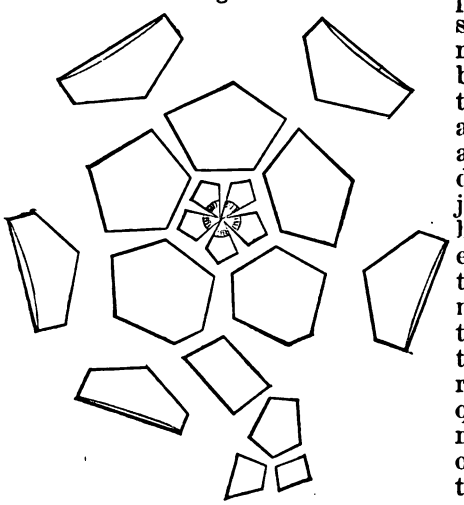
Genus EUPACHYCRINUS, M. & W.

EUPACHYCRINUS VERRUCOSUS, White & St. John.

Hydreionocrinus? verrucosus, White & St. John, 1869, Trans. Chicago Academy of Sciences, Vol. 1, p. 117, Fig. 1.
Eupachycrinus verrucosus, White and St. John, M. S.

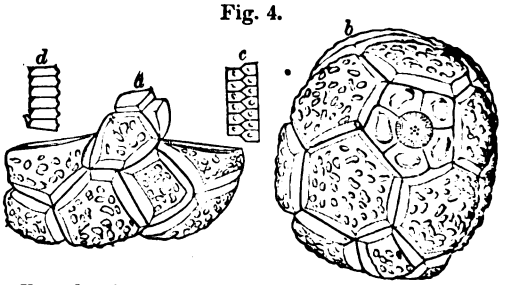
"Body below the top of the first radial plates basin-shaped, with its base slightly depressed, more than twice as wide as high, and composed of somewhat massive, convex plates, which are joined by close sutures, which latter are in the middle moderately deep, caused by the beveling of the edges of the body-plates. Base moderately large, pentagonal, having a little more than one-third its diameter covered by the upper joint of the column. Width and height of subradial pieces about equal, strongly convex from base to top; three of them pentagonal, and two of them hexagonal, there being properly no angle at the base of any of them. First radial plates all pentagonal, not quite so large as the subradials, nearly twice as wide as high, all of them truncated above, so that the top of the calyx is seen to be nearly level when the arms are removed; the facets to which they were attached so broad as to occupy more than half the semi-diameter of the calyx. First anal piece nearly half as large as a subradial, quadrangular, resting between the superior sloping sides of two of the subradials, an inferior sloping side of one of the first radials, and the second anal piece, all of it being below the summit of the calyx. Second anal piece pentagonal, not quite so large as the first, but projecting considerably above the top of the calyx, and bordered by the first anal, one subradial, two first radials, and surmounted by two other small anal pieces. Surface marked by distinct verrucose elevations; and the whole surface, including the sutures, presenting a fine granulated appearance under the magnifier."

Fig. 3.



*Eupachycrinus verrucosus.**—Diagram showing structure of the body, from base to first radials inclusive.

Fig. 4.



Eupachycrinus verrucosus.—*a*, an outline posterior view of the body; *b*, view of under side of same a little distorted; *c*, a view of the dorsal side of a piece of one of the arms; *d*, a lateral view of same, showing the first joint of one of the pinnulæ at the left lower corner.

* I am under obligations to Professor C. A. White, the State geologist of Iowa, for *the use of the type* specimen from which these cuts were made.

Height of body to the top of the first radial pieces, 0.55 inch; breadth of same, about 1.13 inches.

This crinoid agrees nearly, in the number and arrangement of the parts of its body, with the genus *Poteriocrinus*, from the typical species of which, however, its body differs materially in its depressed form and concave base; but it differs more especially in the structure of its arms, which, instead of being each composed of a single series of pieces, consist each of a double series of interlocking pieces. It, therefore, belongs to the same group as *Graphiocrinus* 14-*brachialis* of Lyon (Owen's Kentucky Geol. Rep., Vol. 3, Pl. 1, Fig. 2, 2*a*, and 2*b*), for which Mr. Worthen and the writer proposed the name *Eupachycrinus*, in Vol. 3, Illinois Geol. Rep., p. 177. At one time we had been led to think Mr. Lyon's type might possibly belong to *Hydreionocrinus*, de Koninck. Facts, however, more recently ascertained, in regard to the structure of some analogous American forms, seem to indicate that the part in *Hydreionocrinus* supposed to be composed of the united arms is probably only the ventral portion of the body extended upward.* If this is so, it most probably had free arms; though even in that case we have no evidence that they possessed the structure of those of the type under consideration; and if its *arms* are united to form a kind of extension of the body, as supposed by Professor de Koninck, then the species here described would certainly be widely removed, because the indentations for the attachment of pinnulæ, along their inner sides, show that its arms were free. It also has relations to *Zeacrinus* and *Scaphiocrinus*, from the typical forms of which, however, it differs materially in having its arms composed of a double series of pieces. Specifically this crinoid is closely allied to *Hydreionocrinus tuberculatus* (*Erisocrinus tuberculatus*, Meek & Worthen, from the Coal-Measures of Illinois), which proves to have the structure of arms characterizing this group, instead of that seen in those of *Erisocrinus*. The species under consideration, however, is more delicate, and differs in the peculiar verrucose style of its ornamentation, instead of having a distinctly nodose surface. It also differs in having its sutures more channeled by the beveling of its plates, than the species *tuberculatus*.

Dr. White and Mr. St. John have placed this species in MS. in the genus *Eupachycrinus*.

Locality and position.—The only known specimen of this species was found by Dr. White in the bed No. 2 of the Plattsmouth section, at Plattsmouth, Nebraska.

Genus ARCHÆOCIDARIS, McCoy.

ARCHÆOCIDARIS ? TRISERRATA, Meek.

Pl. 1, Fig. 6 *a*, *b*, *c*.

Of this species I only know the primary spines, but these are so peculiar that they will alone probably be sufficient to distinguish it. They are moderately long, rather slender, and usually a little arched near the base, where they present a nearly or quite circular section. Farther up they soon become compressed with a rhombic section, the lateral margins being sharp and regularly serrated, the little teeth-like projections being inclined outward or toward the apex of the spine, and apparently sometimes alternately arranged. Of these there were probably 25 to 30 on each side of the spine, and 9 to 12 of them may be counted in the

* See remarks of the writer and Mr. Worthen on this subject in Proceed. Acad. Nat. Sci., Philad., Ap. 1870, p. 29.

space of half an inch. On the middle or concave side of the curvature of the spine there is a third serrated carina, apparently extending about two-thirds of its length from near the base toward the apex, the serrations becoming more distantly separated toward the outer extremity. On the other side three or four rows of much smaller granules, or minute, elongated nodes, extend from the shank of the spine, and gradually become obsolete near the middle. The ring at the head is moderately well defined, and, when well preserved, is seen to be faintly milled. The perforation of the abruptly contracted articulating extremity is about one-third as wide as the diameter of the shank. Surface, at least near the shank, where not worn, marked with exceedingly minute longitudinal striæ, entirely invisible without the aid of a good magnifier.

Length, apparently about 2.30 inches. No entire specimens, however, were found.

This species is evidently allied to *A. biangulatus*, Shumard (Trans. St. Louis Acad., 1, p. 223), to which I was at first inclined to refer it. As Dr. S., however, only mentions the two lateral rows of serrations of the primary spines, and says nothing about the others on the upper and lower side, and particularly as he gives the entire number of the serrations on each side as 12 to 14, his species should be distinct.

Locality and position.—Upper Coal-Measures, Omaha, Nebraska; and same position (bed No. 8) in an exposure seen on Platte River, three miles above its mouth. I have also seen a specimen of it from Vermillion County, Illinois, where it was found by Mr. Brodhead, fifty feet below coal-bed No. 6 of the Illinois section. The specimen from Illinois, like that here described, consists of a single spine. Until other parts of the fossil can be known, it is not possible to determine whether or not it is a true *Archæocidaris*.

Genus EOCIDARIS, Desor.

EOCIDARIS HALLIANUS, Geinitz.

Pl. VII, Fig. 9, *a*, *b*, *c*, *d*.

Eocidaris Hallianus, Geinitz, 1866, Carb. und Dyas in Neb., p. 61, Tab. V, Fig. 1 *a*, *b*, 2 *a*, *b*.

Of this delicate little species I have seen only fragments of the spines from Nebraska City and other localities in Nebraska. Entire spines, however, occur on Grand River, Union County, Iowa, in a bed containing many of the same fossils associated with it at Nebraska City, and holding a position about the middle of the Upper Coal-Measures of that region.

Locality and position.—Division C of Nebraska City section.

MOLLUSCA.

POLYZOA.

Genus FENESTELLA, Lonsdale.

FENESTELLA, sp.

Pl. 1, Fig. 4 *a*, *b*.

Fenestella plebeja, Geinitz, 1866, Carbon. und Dyas in Neb., p. 58, Tab. V, Fig. 8 *a*, *b*, (not McCoy, 1844).

I have no specimens of this species for study and illustration, and therefore merely reproduce Professor Geinitz's figures to call attention to the fossil as one of the forms to be looked for in these rocks. I must

differ very decidedly from Professor Geinitz, however, in regard to the identity of this species with *F. plebeja* of McCoy, supposing both forms to have been nearly correctly figured, since they are represented so widely different that very few would think it necessary even to compare them. The differences are too strongly marked to be the result of any errors in the drawings, or due to peculiarities of different varieties of the same species, as may be seen by comparing the published figures of the two forms (see figure of *F. plebeja* copied on Plate VII, Fig. 11, from Professor McCoy's work on the Carboniferous fossils of Ireland, and that here given from Professor Geinitz's Carb. und Dyas in Neb). It is also worthy of note here that Professor McCoy's description agrees exactly with his figure, the fenestrules being represented in both as "rectangular, and from two to three times as long as wide," while in Professor Geinitz's enlarged figure of the Nebraska fossils they are represented without any traces of angles, and of a broad-oval or subcircular form, but slightly longer than wide.

We can never hope for any approximation to precision in paleonlotogy or geology, while such hasty identifications as this are insisted upon by geologists.

Locality and position.—Bellevue and Plattsmouth, in Upper Coal-Measures.

FENESTELLA SHUMARDI, Prout ?.

Plate VII, Fig. 3 *a*, *b*, *c*.

Fenestella Shumardi, Prout, 1858, Trans. St. Louis Acad. Sci., Vol. 1, p. 232.

Polyzoum growing apparently in flabelliform expansions, and composing an extremely fine, delicate net-work; branches very slender, of uniform size, rather flattened, and comparatively coarsely striated on the nonporiferous side, bifurcating at rather regular intervals of from 0.20 to 0.25 inch, the divisions diverging but slightly; fenestrules oblong, or about once and a half to nearly twice as long as wide, distinctly quadrangular, especially as seen on the non-poriferous side, and about equaling the breadth of the branches; dissepiments extremely slender or scarcely more than one-fourth as thick as the branches, not widened at the end on the non-poriferous side, but often somewhat expanded by a pore at one or both ends on the other side. Poriferous side with a mesial carina *apparently* sometimes bearing minute projecting points, and on each side of this angle about two and sometimes three comparatively large pores, generally arranged so that there is one at each end of each dissepiment, and another between these opposite each side of each fenestrule.

Entire size of polyzoum unknown; number of fenestrules in 0.25 inch, measuring longitudinally, 13 to 14; ditto, measuring transversely, 15 to 16; breadth of branches, 0.02 inch.

As near as can be determined from Dr. Prout's description alone, this very delicate little species seems to agree quite well with his *F. Shumardi*, from the Carboniferous limestone (probably of the age of the Coal-Measures) at the Organ Mountain, New Mexico. Still, as it is exceedingly difficult to determine the relations of such fossils with precision from descriptions alone, it is quite possible that the form under consideration may be found distinct on comparison of specimens. If so, I would propose to designate it by the name *F. perelegans*.

Compared with foreign described species, this is perhaps most nearly related to *F. plebeja* of McCoy (Carb. Foss. Ireland, Pl. XXIX, Fig. 3); but on comparison it will be seen to have its fenestrules only once and

a half to nearly twice as long as wide, instead of from two to three times as long as wide, while it has only two or three pores instead of four or five opposite each side of each fenestrule. Its pores are also proportionally larger, while the entire polyzoum forms a more delicate net-work, as may be seen by comparison with a figure of Professor McCoy's species given on Plate VII.

Locality and position.—Division C of the Upper Coal-Measure section at Nebraska City, Nebraska. It has also been discovered by Dr. Newberry in the Lower Coal-Measures of Ohio.

Genus POLYPORA, McCoy.

POLYPORA SUBMARGINATA, Meek.

Pl. VII, Fig. 7 *a*, *b*.

Polypora marginata, Geinitz, 1866, Carb. und Dyas in Neb., p. 69, Pl. V, Figs. 11 *a*, *b*, and 12 *a*, *b*; (not McCoy 1844, Synopsis Carb. Fossils Ireland, p. 206, Pl. XXIX, Fig. 5).
Compare *Fenestella polyporata*, Portlock, 1843, Geol. Londonderry, p. 323, Pl. XXII A, Fig. 1; (not Phillips).

Polyzoum growing in flabelliform (or infundibuliform?) expansions; longitudinal branches bifurcating at more or less regular intervals, and having their lateral margins sharply carinate; dissepiments about half as wide as the branches; fenestrules oblong oval, usually about twice as long as wide, or sometimes proportionally a little wider or longer, their breadth being about the same as the branches. Non-poriferous side with the branches convex, and a little prominent along the middle, flattened toward the carinate lateral margins, and in good specimens finely and beautifully striated longitudinally; dissepiments rounded and sometimes showing faint traces of striæ. Poriferous side with branches provided with a mesial row of small nodes or distinct granules, giving them a subcarinate appearance, and five rows of alternating pores, those of the middle row being placed one between each two of the nodes, while the other four rows are placed two on each side of the middle range; pores sometimes with a slightly raised, very narrow lip, most prominent around the outer side of the lateral ones, which, however, scarcely imparts any irregularity to the outline of the sharp lateral margins; dissepiments obtusely subcarinate along the middle, and sometimes showing traces of striæ, as on the other side.

Entire size of Polyzoum unknown; number of fenestrules, measuring longitudinally, in 0.50 inch, 6; same, measuring transversely, 9 to 11 in same space.

Professor Geinitz refers this species to *P. marginata* of McCoy; but if we are to be guided by Professor McCoy's figures and description, it seems to me we must regard it as being clearly distinct, as may be seen by Figs. 13 *a*, *b*, *c*, copied from Professor McCoy's Synopsis of the Carboniferous Fossils of Ireland. On comparing these with the figures of our fossil, it will be seen that he represents the fenestrules as being proportionally longer, and the dissepiments much more slender. The most important differences, however, may be seen in the enlarged figures of the poriferous sides of the two, as represented by Figs. 7 *b* and 13 *c*. In our species, for instance, there is, when well preserved, a row of distinct little nodes along the middle of each branch, neither represented in the figures nor mentioned in the description of McCoy's species. In addition to this, he mentions in his description, and shows in his figure, waved lines running along between the pores, not seen in the Nebraska species; *and he only* shows 3, or rarely 4, pores in each row opposite each

fenestrule, while in our species there are from 4 to 5, or rarely 6, but generally 5. Surely such differences as this cannot be ignored if we mean to distinguish species at all.

It is true that in the figure given by Professor Geinitz, he shows no traces of the row of little nodes along the middle of the poriferous side; this, however, is due to the fact that his specimen had been subjected to some wearing or abrasion. At any rate, I have before me worn specimens showing the pores very clearly, and having the little nodes entirely removed on some parts, and more or less preserved on other portions of the same; while in others they are as distinct as seen in our enlarged figure. It may be argued that McCoy's figure may have been taken from a worn specimen also; but the fact that it showed the peculiar waved striæ so distinctly between the pores, seems entirely incompatible with the conclusion that it could have suffered such abrasion.

Our species would seem to be more nearly allied to a form referred by General Portlock to *Fenestella polyporata* of Phillips, and cited by Professor Geinitz as a synonym of *P. marginata*, McCoy, particularly as General Portlock mentions seeing on some specimens a row of minute granules along the middle of the branches. The form figured by General Portlock, however, is certainly different from Phillips's species, which is clearly figured with but two rows of pores to each branch, while Portlock's shows four, the one being a *Fenestella*, and the other a true *Polypora*. As General Portlock merely quotes Phillips's meager, unsatisfactory description, and gives a figure very unlike Professor McCoy's, I would neither feel warranted in identifying his species with *P. marginata*, nor in connecting our fossil with either of them.

Locality and position.—The specimens from which our Fig. 7 of Pl. VII were drawn, came from division C of the Nebraska City section, at that place.

POLYPORA, (sp. undetermined).

Pl. VII, Fig. 6.

Polypora biarmica, Geinitz, 1866, Carb. und Dyas in Neb., p. 68, Pl. V, Fig. 13, *a*, *b* (— Keyserling? 1846).

As we found no specimens of this species in division C of the Nebraska City section, I have merely given copies of Professor Geinitz's figures of a specimen from that locality and position. In order that others may have some means of forming their own conclusions in regard to its relations to *P. biarmica* of Keyserling, I have also copied Count Keyserling's figures of his original typical specimen, published in his Petschora Land, Pl. 3, Fig. 10, and 10 a. I can only say these figures look to me exceedingly unlike, and I should not be willing to identify the Nebraska form with the Russian, if the figures are even approximately correct representations of the fossils. In addition to this, the form figured by Professor Geinitz occurs in the unquestionable Coal-Measures of Kansas and Iowa.

Locality and position.—Division C of the Nebraska City section.

Genus SYNOCLADIA, King.

SYNOCLADIA BISERIALIS, Swallow.

Pl. VII, Fig. 5, *a*, *b*, *c*, *d*, *e*.

Synocladia virgulacea?, Swallow, 1858, Trans. St. Louis Acad. Sci., I, p. 179; (not Phillips, 1829).
——— *biserialis*, Swallow, *Ib.*
? Septopora Cestriensis, Prout, 1858, Trans. St. Louis Acad. Sci., I, p. 448, Pl. XVIII, p. 2, 2 *a*, *b*, *c*.
Synocladia virgulacea, Geinitz, 1866, Carb. und Dyas in Neb., p. 70, Pl. V, Fig. 14; (not Phillips, sp.).

Polyzoum infundibuliform? or composed of broad overlapping, or folded, rapidly-spreading flabelliform expansions, attached by a small root-like base. Primary branches, larger than the others, which are alternately and irregularly given off at various angles on each side, and themselves variously divided and subdivided, or rather increased by lateral and intercalated branchlets. Dissepiments, smaller than the branches, usually more or less arched or geniculated, and occasionally giving origin to intermediate branches. Fenestrules, often transversely oblong or irregularly subquadrangular, and usually wider than the branches. Non-poriferous side, with branches and dissepiments rounded, and finely and regularly striated, as well as provided with a few very scattering, irregularly disposed, round, and apparently superficial dimorphous pores, nearly as large as the true pores or cells of the other side; never provided with projecting root-like processes. Poriferous side, with branches and dissepiments, more or less distinctly carinated along the middle, the carina being occupied by a row of little pointed nodes, sometimes rising into short little spine-like projections, with generally on or near the base of each, one or two minute dimorphous pores; true pores or cells moderately large and rounded, with a slightly raised margin; arranged in two rows, one on each side of the carina of each branch and dissepiment, to the lateral margins of which they usually impart a more or less undulated outline; sometimes on the larger primary branches, and some of the larger dissepiments, an occasional odd pore or cell, not properly belonging to either of the two rows, is placed along near the lateral margins, but these never form a third continuous row.

The entire size of the polyzoum is not known, but some of the specimens indicate a diameter of 4 or 5 inches.

This species was regarded by Professor Swallow as a variety of *S. virgulacea*, for which he proposed the name *biserialis*. Professor Geinitz also referred it to *S. virgulacea* of Phillips, without even regarding it as being sufficiently distinct to require separation as a variety. To me, however, it seems to present differences of too much importance to admit of being included even as a variety of *S. virgulacea*. In order the more clearly to illustrate these differences, I have given on Plate VII, Fig. 12 *a*, a copy of a part of Professor King's enlargement of the poriferous side of *S. virgulacea* for comparison with Fig. 5, *d*, an enlargement of a portion of the same side of the Nebraska fossil. On comparing these, it will be seen that *S. virgulacea* has no mesial carina and is provided with three or more rows of pores or cells (Professor King says, in his description, from 3 to 5), arranged in longitudinal furrows, the middle one of which is bounded on each side by a slight carina, with small, minutely poriferous nodes; the entire arrangement being very different from the characters *constantly* presented by the Nebraska species. In addition to this, so far as yet known from the examination of numerous specimens, the

latter never shows any traces of the root-like process of the non-poriferous side, so often seen on *S. virgulacea* (See Pl. VII, Fig. 12, *b*); while it constantly shows on this side a few scattering, irregularly-arranged dimorphus pores, neither mentioned in any of the descriptions, nor illustrated in any of the figures of the European species I have seen. For these reasons I can but regard it as a clearly distinct species. Like the European *S. virgulacea*, the species under consideration varies in the arrangement of its branches, fenestrules, and dissepiments, to some extent, though it is constant in its other characters.

Locality and position.—The specimens figured on Pl. VII are from division C, of the Nebraska City section; those on Pl. IV are from a shaft at that place, sunk some distance below this horizon, probably below division B, in which it also occurs. We also have it from a lower position at various localities in the Upper Coal-Measures of Kansas and Nebraska, Iowa, &c.; while in Kansas it ranges up into the Permo-carboniferous, and possibly into the Permian. In Illinois it occurs in both the Upper and the Lower Coal-Measures; and we have there also found an undistinguishable form in the St. Louis and Chester limestones, of the Lower Carboniferous series. (See Proceed. Acad. Nat. Sci., Philad., March, 1870, p. 15.)

Genus GLAUCONOME, Goldfuss.

GLAUCONOME TRILINEATA, Meek.

Pl. VII, Fig. 4, *a*, *b*, *c*, *d*.

Compare *Glauconome grandis*, McCoy, 1844, Carb. Foss. Ireland, p. 199 Pl. XXVIII, Fig. 3.

Polyzoums with main stem long, slender, and, as far as known, of equal breadth the entire length, not quite twice as wide as the lateral branches. Lateral branches, long, rather rigid, sometimes alternating, and, in other examples, nearly opposite, distant from each other slightly more than the breadth of the main stem, with which they range at an angle of about sixty degrees; like the main stem, showing no taper as far as known; sometimes themselves giving off (at least on the lower side) a few distant lateral subdivisions, at some distance out from the main stem. Non-poriferous side, with main stem and branches minutely and very regularly striated longitudinally. Poriferous side, with a mesial ridge along the main stem, consisting of three slightly-raised lines, the middle one of which is larger than the others; on each side of this ridge is a row of pores, three of which are placed between each two of the lateral branches, and about their own breadth from the margin, to the outline of which they do not impart any irregularity; lateral branches with, on each side of a linear ridge, two rows of alternating pores, very slightly smaller than those of the main stem, and imparting sometimes a slightly undulated outline to the margins.

Entire length unknown; a specimen imperfect at both extremities 1.24 inches in length, sending off on each side six lateral branches in a space of 0.27 inch.

This may not be distinct from Professor McCoy's species, which is certainly a very closely allied form. As the main stem of our fossil, however, shows on the poriferous side, three longitudinal mesial-raised lines or ridges, as seen under a good magnifier, and nothing of the kind is mentioned in the description or shown in the figures of *G. grandis*, I do not feel warranted in identifying the Nebraska species with it. There are, also, some differences in the angle at which the lateral branches are given ff, as well as in the *number of pores*, that indicate a specific difference.

The presence of a secondary branchlet seen on one of our specimens may be another indication of further differences, though as this is only given off farther out from the main stem than the lateral branches are preserved in the specimen figured by Professor McCoy, they may really exist in his species.

Locality and position.—Division C, at Nebraska City.

BRACHIOPODA.

Genus LINGULA, Bruguiere.

LINGULA SCOTICA, *var.* NEBRASCENSIS.

Pl. VIII, Fig. 3, *a*, *b*.

? *Lingula Scotica*, Davidson, 1860, Monogr. Carb. Brach., Scotland, p. 62, Pl. 5, Fig. 36, 37, and 37 *a*.

Shell attaining nearly a medium size, compressed, subovate or ovoid-subtrigonal, a little longer than wide, the greatest breadth being near the anterior margin; front rather broadly rounded, or at maturity somewhat more nearly straight along the middle, rounding rather abruptly into the antero-lateral margins; sides convex in outline and converging (near the beaks) at an angle of about 90°; beaks rather obtusely pointed and a little convex. Surface polished and ornamented by prominent, linear concentric ribs or striæ, separated by flat spaces three or four times as wide as the ribs, in which traces of much finer, obscure irregular concentric striæ can be seen by the aid of a magnifier. Internal cast nearly smooth, excepting three or four radiating linear impressions near the beak, apparently formed by little ridges on the inner side of the shell, but which are sometimes made visible on the outside, apparently in consequence of accidental pressure upon the thin shell.

Length, 0.55 inch; breadth, 0.49 inch.

This shell is so very nearly like *L. Scotica*, Davidson, from the Carboniferous rocks of Scotland, that I cannot, with the present means of comparison, regard it as more than distinguishable as a variety of that species. Its chief differences consist in its greater breadth in proportion to its length, and the more convex outline of its lateral margins, together with the larger size of its concentric lines. The former characters cause the beak to be rather distinctly less attenuated. As I have seen but a single specimen, I have no means of determining whether it is the shorter or longer valve from which the figure and description have been prepared.

Locality and position.—Lower part division C, Nebraska City.

Genus ORBICULOIDEA, d'Orbigny.

ORBICULOIDEA, sp.

Pl. IV, Fig. 3.

I only know this species from an impression of the outside of the under valve in the clay matrix, with adhering portions of the shell, showing the inside. The outline of the valve is broad ovate, the posterior end being the narrower. It is rather convex in the region of the apex, and flat, or even slightly concave, between that and the anterior margin. The apex is situated between the middle and the posterior side, but nearer the former. The surface is ornamented by very regular, distinct concentric striæ, some of which bifurcate as they pass around the sides from the posterior toward the rather broadly-rounded front.

The remaining portion of the shell, between the apex and the posterior margin, shows very clearly that there is not a slit passing through

the valve, as in true *Discina*, though there is evidently a deep furrow on the outside of the valve passing from the apex a little more than half-way to the posterior margin, at which point there was a small round or oval foramen. On the inside a prominent smoothly-rounded ridge (*d*, of Fig. 3) corresponds to the deep furrow on the outer side. The shell is quite thin and has the usual dark semi-corneous appearance of *Discina*. It is possibly an undescribed species, but not having the means of fully characterizing it, I propose no name for it at present.

Anterio-posterior diameter, 0.64 inch; breadth, 0.55 inch.

Locality and position.—The specimen figured and described was found in sinking a shaft on Hon. J. S. Morton's place, one and three-quarters miles west of Nebraska City landing.

Genus PRODUCTUS, Sowerby.

PRODUCTUS COSTATUS, Sowerby ??sp.

Pl. VI, Fig. 6, *a*, *b*.

? *Producta costata*, J. D. C. Sowerby, 1827, Min. Conch., Pl. 560, Vol. VI, p. 115; Phillips, 1836, Geol. Yorks., 11, p. 213, Pl. VII, Fig. 2.
—— *costellata*, McCoy, 1844, Synopsis Carb. Foss., Ireland, p. 108, Pl. XX, Fig. 15.
—— *costatus*, de Verneuil, 1845, Geol. Russ. et Ural Mts., Vol. II, p. 268, Pl. XV, Fig. 13, *a*, *b*; de Koninck, 1847, Monogr. Prod. Pl. VIII, Fig. 3, and Pl. X, Fig. 3; Davidson, 1860, Monogr. Scott. Carb. Brach., p. 44, Pl. II, Figs. 22–24; also Monogr. British Carb. Brach., p. 152, Pl. XXX, Figs. 2–9; Shumard, 1855, Missouri Geol. Report, p. 216; Hall, 1858, Iowa Geol. Report, Vol. I, Part II, p. 712, Pl. XXVIII, Figs. 3 and 4.
—— *Portlockianus*, Norwood & Pratten, 1854, Journ. Acad. Nat. Sci. Philad., III, p. 15, Pl. 1, Fig. 9, *a*, *b*, *c*.
—— sp., Prof. Henry D. Rogers, 1858, Geological Report, Pennsylvania, Vol. II, p. 833, Fig. 687.

Shell of medium size, wider than long, very convex; hinge margins about equaling the greatest breadth of the valves. Ventral valve exceedingly gibbous, and very strongly incurved, with a deep-rounded sinus extending from near the beak to the front, to which it imparts a sinuate outline; umbo prominent and distinctly incurved, so as to pass somewhat within the hinge margin; ears well-defined, arched, and rather distinct from the abrupt swell of the umbo, from which they are sometimes separated by a small ridge or fold. Dorsal valve flattened in the visceral region, and more or less abruptly curved or geniculated toward the front and anterior lateral margins, the former of which usually shows a small mesial ridge. Surface of both valves ornamented with distinct, rather unequal, depressed, and rounding radiating costæ, which sometimes bifurcate, or, in other instances, two or more of them coalesce in front of the visceral portion, to form a larger one; crossing all of these, on the visceral region, are numerous, well-defined, regular, concentric wrinkles, producing a distinct reticulated appearance, while the whole surface of the ventral valve is sometimes provided with a few scattering, rather stout, erect spines, somewhat regularly arranged in quincunx. Sometimes nearly all the spines, excepting those on the lateral regions, apparently wanting.

Length of a medium-sized adult specimen, 1.06 inches; breadth, about 1.40 inches; convexity, about 0.70 inch.

This is the shell that has been in this country very generally identified with *P. costatus* of Sowerby, though its identity with the typical *P. costatus* may be questioned. At least I have never seen among thousands of specimens from numerous localities a single example of it presenting the large costæ and the extravagant forms sometimes assumed by that shell at foreign localities, such, for instance, as that figured on Pl. XV,

Fig. 13, of the Geology of Russia. The form under consideration is quite constant in its adult size and general characters. Its ribs vary more or less, being often irregular in size, some being rather distinctly larger than the others on the anterior slope, though this character is not well seen in the specimen figured, because the anterior edge of the valves is partly broken away, and the figures are not drawn in postures to show the anterior slope.

Some years since I sent specimens of this shell to Mr. Davidson, the well-known English authority on the *Brachiopoda*, and he wrote back that he did not think it could be *P. costatus*, but that he thought it more probably a small variety of *P. semireticulatus*. This may be true, and yet it is curious that we find hundreds of specimens of this shell, often directly associated with well-defined examples of *P. semireticulatus*, and still always readily distinguished at a glance by their smaller size and rather more unequal costæ on the anterior slope. It cannot be that these are the *young* of *P. semireticulatus*, because they give every evidence, in their gibbous form and produced front, of being adult shells.

Locality and position.—The specimens figured are from the division B of the Nebraska City section. We also found this form in what has been regarded as the same position (but as we believe at a higher horizon), two and one-half miles west of Nebraska City; at Wyoming, and again at the horizon of bed B at Bennett's Mill, and still lower at Rock Bluff, Cedar Bluff, Plattsmouth, Bellevue, Omaha, and, in short, throughout the Coal-Measures of all this region. It likewise ranges through the whole of the Coal-Measures of Illinois, Missouri, Iowa, &c., though I am not quite sure that it occurs in any of our Lower Carboniferous rocks. Professor Rogers has also figured apparently the same fossil from the Coal-Measures of Pennsylvania.

PRODUCTUS SEMIRETICULATUS, Martin, sp.

Pl. V, Fig 7 *a*, *b*.

Anomites semireticulatus, Martin, 1809, Petref. Derb., p. 7, Pl. XXXII, Figs. 1, 2, and Pl. XXXIII, Fig. 4.
——— *productus*, Martin, 1809, ib., p. 9, Pl. XXII, Figs. 1–3.
Productus scoticus, Sowerby, 1814, Min. Conch., Pl. LXIX, Fig. 3, and ib., Pl. 317, Figs. 2–4.
——— *antiquatus*, Sowerby, 1814, ib., p. 15, Figs. 1–5; Phillips, 1836, Geol. Yorks., p. 213, Pl. VII, Fig. 1.
——— *semireticulatus*, de Koninck, Mon. Gen. Prod., Pl. VIII, Fig. 1, and Pl. IX, Fig. 1, and Pl. X, Fig. 1; also of Davidson, Salter, and others.
Producta Martini, Phillips, 1836, Geol. Yorks., Vol. II, p., 213, Pl. VII, Fig. 3; de Koninck, 1843, An. Foss. Carb. Belg., p. 160, Pl. VII, Fig. 2.
——— *pugilis*, Phillips, 1836, Geol. Yorks., Vol. II, p. 215, Pl. VIII, Fig. 6.
Leptæna antiquata, Fischer, 1837, Oryct. du Gouv. de Mosc., Pl. XXVI, Figs. 4–5.
——— *tubifera*, Fischer, 1837, ib., XXVI, Fig. 1; (not Deshayes).
Productus Inca, d'Orbigny, 1843, Paleont. Voyage dans Am. Merid., Vol. III, p. 51, Pl. IV, Figs. 1–3.
Producta flexistria, McCoy, 1844, Carb. Foss., Ireland, p. 109, Pl. XVII, Fig. 1.
Productus Calhounianus, Swallow, 1858, Trans. St. Louis Acad. Sci., 1, p. 181.*

This beautiful, and widely distributed species is too well known to require a detailed description or any comparisons. So far as I have been able to see, after examining numerous specimens from various places in our western Carboniferous rocks, at different horizons, I am not able to see any characters by which these American shells can be separated from the well-known European *P. semireticulatus*.

*The foregoing synonymy is adopted mainly from Mr. Davidson, Monogr. Brit. Carb. Brach.

I am satisfied that the form described by Professor Swallow, under the name *P. Calhounianus*, cannot be separated from *P. semireticulatus*; at least I know of no well-defined characters by which it can be distinguished, although I at one time rather inclined to think it might be distinct.

Locality and position.—Professor Geinitz mentions this species among the other fossils from division C of the Nebraska City section, and I remember finding an imperfect specimen of it in that horizon at that locality; but it was crushed to pieces in transporting the collections to Washington. It also occurs at apparently a higher horizon, 2¾ miles west of Nebraska City. The specimen figured on Pl. V is from division B of the Nebraska City section, where we found it quite abundant, as well as at Bennett's Mill, Wyoming, &c. This large variety also occurs at numerous lower horizons in the Upper Coal-Measures of Nebraska; such, for instance, as at Cedar Bluff on Weeping Water, and Rock Bluff, Bellevue, Omaha, and Plattsmouth; and again at higher horizons at Brownville, Peru, Aspinwall, &c., on the Missouri, as well as at various localities in the interior. It is also common in the Upper and Lower Coal-Measures of Iowa, Illinois, Kansas, Missouri, and south to New Mexico; and it is widely distributed in the Carboniferous rocks of Europe, South America, India, &c. It is likewise common at various horizons in our western Lower Carboniferous rocks.

PRODUCTUS LONGISPINUS, Sowerby ?

Pl. VI, Fig. 7, and Pl. VIII, Fig. 6, *a*, *b*, *c*.

Productus longispinus, Sowerby, 1814, Mineral Conch., Vol. I, p. 154, Pl. LXVIII, Fig. 1; de Koninck, 1843, An. Foss. Ter. Carb. Belg., p. 187, Pl. XII, Fig. 11, *a*, *b*, and Pl. XII *bis*, Fig. 2; Davidson, 1853, Introd. Brit. Foss. Brach., Pl. IX, Fig. 221; 1860, Monogr. Carb. Brach., Scotland, p. 39, Pl. II, Figs. 10 to 19.
——— *Flemingii*, Sowerby, 1814, Min. Conch., Vol. I, p. 154, Pl. LXVIII, Fig. 2; de Koninck, 1847, Monogr. Prod. and Chonetes, Pl. X, Fig. 2; Marcou, 1858, Geol. N. Am., p. 47, Pl. VI, Fig. 7.
——— *spinosus*, Sowerby, 1814, Min. Conch., Vol. I., p. 155, Pl. LXIX, Fig. 2.
——— *lobatus*, Sowerby, 1814, ib., Vol. IV, p. 16, Pl. 314, Figs. 2–6; Von Buch, 1841, Verhandl. der Königl. Akad. der Wissensch. zu Berlin, Theil, 1, p. 32. Pl. II, Fig. 17; de Vern., 1845, Geol. Russ., Vol. II, p. 266, Pl. XVI, Fig. 3, Pl. XVIII, Fig. 8.
——— *setosa*, Phillips, 1836, Geol. Yorks., Vol. II, p. 214, Pl. VIII, Fig. 9.
——— *capacii*, d'Orbigny, 1843, Voyage dans l'Amerique, Mer., Vol. III, p. 50, Pl. III, Figs. 24–26.
——— *tubarius*, de Keyserling, 1846, Petschora Land, p. 208, Pl. IV, Fig. 6.
——— *Wabashensis*, Norwood & Pratten, 1854, Jour. Acad. Nat. Sci., Philad., Vol. III, new. ser., p. 13, Pl. I, Fig. 6.
——— *splendens*, N. & P., 1854, ib., p. 11, Pl. 1, Fig. 5.
? ——— *muricatus*, N. & P. 1854, ib., p. 14, Fig. 8, *a*, *b*, *c*, *d*, *e*; (not of Phillips and others).
———*Orbignyanus*, Geinitz, 1866, Carb. und Dyas in Neb., p. 56, Tab. IV, Figs. 8, 9, 10, 11; (not de Koninck, 1848).
——— *horridus* Geinitz, 1866, ib., Fig. 7; (not Sowerby, 1822).

Shell small, thin, wider than long; hinge line generally longer than the transverse diameter of the valves at any point farther forward, and terminating in more or less distinct, rather vaulted, and often slightly reflexed ears; anterior and anterior-lateral outlines approaching a semicircular curve, but the middle of the front is generally rather distinctly sinuous. Ventral valve gibbous, the greatest convexity being usually behind the middle, and the curve to the beak more rapid than to the front, provided with rather deep mesial sinus; posterior-lateral slopes descending nearly vertically to the ears; umbonal region moderately prominent, and usually projecting rather distinctly beyond the hinge, as seen in looking down upon the shell when lying with the dorsal valve beneath; beak small, *strongly curved*, but scarcely passing beyond the

cardinal margin; surface ornamented with generally rather obscure, somewhat variable radiating costæ, which are often obsolete in the umbonal region, or in some examples over much of the valve farther forward, in other specimens quite distinct to the beak, sometimes bifurcating, and in other instances coalescing to form larger, faintly-defined ribs in front; fine indistinct marks of growth are also sometimes seen, and occasionally very obscure traces of small, concentric wrinkles may be observed near the beak; spines stout, erect, long, scattering, and arranged in quincunx. Ventral valve distinctly concave, or following nearly the curve of the other, and provided with a small mesial ridge corresponding with the sinus of the latter; surface marked as in the other valve, but apparently always without spines.

Length of a medium-sized adult specimen, 0.41 inch; breadth, 0.61 inch; convexity, 0.30 inch.

I follow Mr. Davidson in referring this little shell to *P. longispinus* of Sowerby, a conclusion arrived at by him after a comparison of authentic specimens sent from Illinois by Mr. Worthen, from some of the original localities of *P. splendens* and *P. Wabashensis*, N. & P. At first I was in some doubt whether or not our Nebraska shell is identical with the *P. Wabashensis*, on account of the costæ being represented so fine, distinct, and regular, and with so few spine bases, on Norwood & Pratten's figures, but on comparison with good specimens of that species from their original locality, I am entirely convinced that our shell is in all respects identical, the figures of *P. Wabashensis* alluded to being quite defective in representing the costæ, as stated above.

In regard to the identity of this shell with *P. Orbignyi*, I am compelled to differ from Professor Geinitz. I am also satisfied, as elsewhere stated, that the little shell figured by Professor Geinitz under the name *P. horridus* on his Pl. IV (Carb. und Dyas. in Nebraska), and copied on our Plate VIII, Fig. 6, *b*, *c*, is nothing but a young individual of the species under consideration. As already stated, this shell varies much in the distinctness of its costæ, which are usually rather obscure. It is but necessary to examine a few good specimens to see by their smooth, non-costate umbonal region, that they often attain a size even greater than that he has referred to *P. horridus*, without showing the slightest traces of radiating costæ. Indeed, some individuals of mature size show but faint indications of ribs even near the front margin, while the various individuals present every intermediate gradation in this character between these and the most distinctly ribbed specimens. In addition to this, the extreme improbability of there being in these rocks a large, conspicuous species like *P. horridus*, when no traces of such a shell have ever been seen among all the vast collections that have been obtained from them throughout the great area in which they occur in the West, would alone be a sufficient reason for rejecting the conclusion that such a mere mite as this is the young of that species. But the necessity for such an improbable conclusion is entirely removed by the fact that this specimen was found associated with a very common and abundant species, the young of which evidently agrees exactly with it.

Locality and position.—Nebraska City, division C (Geinitz); also in B at that place, Wyoming, Bennett's Mill, and lower at Rock Bluff, Cedar Bluff, Plattsmouth, Bellevue, and Omaha—in short, this species is found almost everywhere and at nearly all horizons in the Upper Coal-Measures of Nebraska, and in the upper, middle, and lower divisions of Iowa, Illinois, Kansas, Missouri, &c. We have no good specimens of it from division C at Nebraska City, and consequently reproduce Professor Geinitz's figures of individuals from that bed. We have good examples of it,

lowever, from division B at Nebraska City, and the other localities nentioned above.

PRODUCTUS PRATTENIANUS, Norwood.

Pl. II, Fig. 5, *a, b, c;* Pl. V, Fig. 13; and Pl. VIII, Fig. 10, *a, b.*

'oductus *semireticulatus*, Hall, 1852, Stansbury's Salt Lake Report, p. 411, Pl. III, Figs. 4 and 5; (not Martin, sp., 1809).
— *Prattenianus*, Norwood, 1854, Jour. Acad. Nat. Sci. Philad., Vol. III, new ser., p. 17, Pl. I, Fig. 10. *a, b, c, d.*
— *æquicostatus*, Shumard, 1855, Missouri Geol. Report, p. 201, Pl. C, Fig. 10.
— *cora*, Marcou, 1855, Geol. N. Am. Pl. VI, Figs. 4 and 4 *a;* (not d'Orbigny).
— *Flemingii*, Geinitz, 1866, Carb. und Dyas in Neb., p. 52, Tab. IV, Figs. 1, 2, 3, 4; (not Sowerby, 1814).
— *Calhounianus*, Geinitz, 1866, *ib.*, p. 81; (not Swallow, 1858).
— *Koninckianus*, ? Geinitz, 1866, *ib.*, p. 53, Tab. IV, Fig. 5, *a, b;* (not de Vern. 1845).

Shell attaining a medium size; breadth generally exceeding the length, pecially when the ears are entire; cardinal margin usually somewhat ıger than the transverse diameter of the valves at any point farther ·ward; anterior and antero-lateral outline regularly rounded. Ventral lve distinctly and rather evenly convex, and without any traces of a ısial sinus; umbonal region gibbous; beak incurved, but scarcely ssing the hinge margin; ears large, rather compressed, and provided th a few large, strongly defined, concentric folds, which ascend a little on the sloping sides of the umbo, and extend more or less along the sterior lateral margins, but never cross the beak, central region, nor ınt; surface ornamented with rather small, regular, rounded costæ or iæ, and armed with stout, erect, long spines, usually arranged over ə whole valve in quincunx, while one or two rows along the hinge margin ə more crowded, larger, and in part directed backwards, with an ·ard curve.* Dorsal valve concave, sometimes a little flattened in the ıceral region, and following the curve of the other valve around the ınt and anterior lateral margins; ears with folds as in the other valve, d each separated from the concave central region by an oblique ridge prominence; surface without spines, but with radiating striæ as in ə ventral valve, and usually crossed by very obscure concentric inkles and a few embricating concentric marks of growth, particularly ar the front and sides; cardinal process small, but slightly prominent, d bifid, while from its base a slender linear mesial ridge extends for- rd to, or a little beyond, the middle. Muscular and reniform impres- ns very obscure or obsolete in the specimens examined.

Length of a well-developed, medium-sized specimen, 1.40 inches; eadth, 1.47 inches; convexity, about 0.85 inch.

This species has been often referred to *P. cora*, d'Orbigny, from which, wever, it differs (especially from the form referred to that species by ropean authors) in its greater convexity, more extended hinge, and ıch longer and stouter spines. It likewise differs from d'Orbigny's ginal figure of the South American type of that species, given in his leont. Voyage, dans l'Amerique Meridionale, Pl. 5, in several im- rtant characters. The fact, however, that M. de Koninck and others er a European form to d'Orbigny's species, also differing widely from ə figures of the South American shell alluded to, after having seen)rbigny's typical specimens, shows that he must have figured it incor- tly, and that we should possibly look more to the figures given by . Davidson and M. de Koninck of the European form compared with

In a few specimens they seem to be wanting over the greater part of the more con- region of the valve.

d'Orbigny's typical specimens, than to his own figures, in forming an idea of the true characters of *P. cora*.

Professor Geinitz has referred the species under consideration in part to *P. Flemingii*, of Sowerby, which Mr. Davidson says, after seeing Sowerby's type of that supposed species, was founded upon a bad specimen of the common *P. longispinus*. Some of the young individuals of *P. Prattenianus* look more or less like *P. longispinus*, but it is only necessary to have a good series of the Nebraska shell, of various sizes, for comparison, to be convinced that it is entirely distinct from *P. longispinus*. I am also compelled to differ from Professor Geinitz, in regard to the shell represented by Fig. 5, Pl. IV, of his Carb. und Dyas, being the *P. Koninckianus*, de Verneuil, a much smaller species, with a more prominent umbo, and a distinctly shorter hinge. To me, the shell figured under this name by Professor Geinitz seems to agree exactly with the usual adult characters of *P. Prattenianus*, but in order that others may have the means of forming their own conclusions on this point, I have given a copy of Professor Geinitz's figure (the ears of which I have restored in outline), and for comparison a copy of Mr. Davidson's figure of *P. Koninckianus*, from his Monogr. Brit. Carb. Brach., Pl. LIII, Fig. 7, natural size. Mr. Davidson's figure was drawn from a British specimen; but in the prominence of its beak and the shortness of its hinge, M. de Koninck's figure of a Belgian specimen of *P. Koninckianus* (under the name *P. cancrini*, but now generally regarded as the same as *P. Koninckianus*) differs in a more marked degree than Mr. Davidson's. The only figures I have seen of a Russian specimen of *P. Koninckianus* are those given by Count Keyserling, in his Petschora Land, Tab. IV, Fig. 4, *a*, *b*, *c*. These also show the umbo to be extremely prominent, and look in all respects quite unlike the Nebraska shell. It is also worthy of note that all of these authors both figure and describe the *P. Koninckianus* as a neat, pretty little species of the size of Mr. Davidson's figure, copied for comparison on our Plate V, Fig. 15, *a*, *b*, *c*.

Having only crushed and imperfect specimens of this shell from division C of the Nebraska City section, I have given on Pl. VIII, among the other fossils from that horizon, copies of two of the figures of this shell, published by Professor Geinitz in his Carb. und Dyas, Pl. IV.

Locality and position.—Divisions C and B of the Nebraska City section at that place, and in division B at Bennett's Mill; also at lower horizons at Cedar Bluff, Plattsmouth, Bellevue, Omaha, and, in short, at numerous other localities in the Upper Coal-Measures of Nebraska, Kansas, and Iowa, and in both Upper and Lower Coal-Measures of Illinois.

PRODUCTUS PERTENUIS, Meek.

Pl. I, Fig. 14, *a*, *b*, *c*, and Pl. VIII, 9 *a*, *b*, *c*, *d*.

Productus cancrini, Geinitz, 1866, Carb. und Dyas in Neb., p. 54, Tab. IV, Fig. 6, *a*, *b*, *c*, *d*; (not Murch. de Vern. and Keys., Geol, Russ., Vol. II, part Paleont., Pl. XVI, Fig. 8, *a*, *b*, *c*, and Pl. XVIII, Fig. 7).

Shell small, very thin, truncato-subhemispherical; sides and front regularly rounded; hinge line usually rather less than the greatest breadth of the valves. Ventral valve without any traces of a mesial sinus, moderately gibbous, the greatest convexity being slightly behind the middle, from which point it rounds off in all directions, but most abruptly to the beak and ears, which latter are flattened and subrectangular; beak small, slightly prominent, and but little incurved beyond the hinge line; surface with fine, regular, radiating striæ, crossed by small, rather distinct and regular, concentric wrinkles, which latter are

generally most strongly defined on the ears; over the whole there are also regularly arranged in quincunx, very slender spines, 0.20 to 0.30 inch in length, rising from slight prominences or swellings of the radiating striæ. Dorsal valve distinctly concave, or following nearly the curvature of the other valve, its greatest concavity being in the central region, while its ears are nearly flat; surface with concentric wrinkles and radiating striæ as in the other valve, but apparently without spines, though a series of rather distinct pits are arranged over it in the same order as the spines of the other valve.

Length of one of the largest specimens seen, 0.46 inch; breadth, 0.57 inch; convexity, about 0.24 inch.

I have known this little shell since 1858, but had never been able to identify it with any of the known species, nor yet to feel sure that it was new, and consequently left it without a name in the Kansas collections, fearing it might be the young of some of the larger analogous forms. The comparisons, however, that I have recently had an opportunity to make, of a series of specimens from different localities, have satisfied me that it must be an adult shell, and as it cannot be properly identified with any of the described species, so far as yet known, I have ventured to regard it as new.

Professor Geinitz has referred it to *P. cancrini* of M. V. & K., which it certainly resembles quite closely in some of its characters. But its dorsal or smaller valve (ventral of some authors) is certainly *distinctly concave*, particularly in the visceral region, while this valve in *P. cancrini* is described as having its "disk entirely flat." It is an exceedingly thin shell, and the concavity of the smaller valve follows so closely the curve of the other, that the space occupied by the soft parts of the animal was very contracted.

As the only specimens in the collection under investigation from division C, of Nebraska City, are in a crushed condition, I have reproduced the figures 9, *a*, *b*, Pl. VIII, given by Professor Geinitz. Fig. 14, *a*, *b*, of Pl. I, however, are from a specimen obtained at another locality.

Locality and position.—Division C, of Nebraska City section, and from a shaft at that place, possibly below that horizon; also at Brownville, Nebraska, and a lower position at Atchison, Kansas. We likewise found it in 1858 in the Upper Coal-Measures on Grasshopper Creek, twelve miles west of Leavenworth, Kansas.

PRODUCTUS NEBRASCENSIS, Owen.

Pl. II, Fig. 2; Pl. IV, Fig. 6; and Pl. V, 11 *a*, *b*, *c*.

Productus Nebrascensis, Owen, 1852, Geol. Report, Wisconsin, Iowa, and Minnesota, p. 584, Pl. V, Fig. 3*; 1867, McChesney, Trans. Chicago Acad. Sci. 1, p. 24, Pl. I, Fig. 7.

——— *Rogersii*, Norwood & Pratten, 1854, Jour. Acad. N. S. Philad., Vol. III, new series, p. 9, Pl. I, Fig. 3, *a*, *b*, *c*; Hall, 1856, Vol. III, Pacific R. R. Report, p. 104, Pl. II, Figs. 14, 15.

——— *asper*, McChesney, 1860, Descr. New Palæozoic Fossils, p. 34; also illustrations same, 1865, Pl. I, Fig. 7 *a*, *b*.

Strophalosia horrescens, Geinitz, 1866, Carb. und Dyas in Neb., p. 81; (not Murch. de Vern. and Keyserling, 1845).

Shell of about medium size, approaching subhemispherical; length most usually a little less than the breadth; hinge line nearly or quite equaling the greatest transverse diameter; anterior outline nearly straight, or a little sinuous near the middle, rounding into the lateral

* This figure is *very* imperfect and gives no idea of the surface characters of the species.

margins, which are generally rather straight posteriorly, and ranging at an angle of from ninety to about one hundred degrees with the hinge; ears nearly rectangular, or a little rounded in outline, at their immediate extremities.

Ventral valve rather convex, most gibbous behind the middle, thence rounding regularly to the front and more abruptly to the beak, generally with a moderately distinct mesial sinus; posterior lateral slopes descending almost vertically to the ears; umbonal region gibbous, and with the strongly incurved beak projecting beyond the hinge line.

Dorsal valve somewhat flattened in the visceral region, but most concave near the beak and toward the anterior lateral regions, the concavity widening rapidly forward, so as to leave a kind of broad, obscure, oblique ridge between it and the flattened ears, and another in the middle; anterior and lateral margins following the curvature of the other valve; cardinal process prominent, bifid, and rather narrow; interior with mesial ridge, narrow, well defined, extending forward beyond the middle, and a little bifid at its connection with the base of the cardinal process; muscular and reniform impressions obscurely marked; interior surface with numerous pustular projections which are most prominent and pointed on a belt around near the anterior and lateral margins.

Surface of ventral valve with more or less defined, rather broad concentric undulations, and obscure striæ of growth, over the whole of which are arranged two sets of spines, connected at their bases with short interrupted ribs or elongated tubercles. One of these sets consists of small, short, appressed spines, and the other of stout, more erect, long ones. Surface of dorsal valve with small concentric ridges and striæ, with many little pits; spines nearly or quite all small, short and appressed.

Some confusion, in regard to the limits and relations of this species, has arisen from the differences presented by specimens, as broken from a hard limestone matrix, and the perfect shell as found weathered out of clay or soft shale. In the former case the spines, and nearly or quite all of the shell, are usually left in the matrix while the internal cast, when thus denuded, shows the concentric undulations and longitudinal ridges or elongated pustules, more strongly defined, with little indications of the spines. On the contrary, specimens from clay or shale are often found with the shell entire, and preserving the spines in a more or less perfect condition, so as to obscure, to some extent, the little interrupted ribs and concentric undulations.

The specimens first described by Dr. Owen, as I know from a careful examination of his types, kindly loaned to me by his brother, Professor Richard Owen, are from limestone and only show traces of the spines. Partly from this fact, and probably in part from an error of the engraver, Dr. Owen's published figure gives a *very* incorrect idea of the shell, though his description, and comparison with *P. Humboldti*, when taken in connection with the locality from which his specimen was obtained (Bellevue, Nebraska), would satisfy any one, familiar with the fossils of that region, that he must have had before him the form under consideration, even if his original types were lost.

The specimen upon which the species *P. Rogersii* was proposed, which I have also had an opportunity to examine, through the kindness of Professor McChesney, to whom it belongs, is also an internal cast showing the rib-like pustules and concentric undulations very clearly, but without any traces of the spines.

The specimens upon which Professor McChesney proposed the species *P. asper* are well preserved and retain much of the spines. I have not

seen these identical specimens, however, but have had an opportunity to examine a large collection, consisting of several hundred individuals, belonging to Professor Powell, of Bloomington, Illinois, from the same locality and position at Lasalle, of that State. From these and numerous others, in all conditions, I have seen from various localities in the West, I have no hesitation in regarding *P. asper* as also synonym of *P. Nebrascensis*.

Professor Geinitz was certainly in error in referring this shell to *Strophalosia horrescens*, since it is positively not a *Strophalosia* at all, but a true *Productus*, as may be seen by the figures on plate V. It never has any traces of the cardinal area of the genus *Strophalosia*, as I know from a careful examination of hundreds of well-preserved specimens, its cardinal margin being linear, as may be seen by Fig. 11, *c*, of Plate V. By comparing this with Fig. 14 of the same plate, representing *Strophalosia horrescens*, from Professor Geinitz's work on the German Permian fossils (Dyas), the external difference between this genus, and *Strophalosia*, will be at once seen by the student, the latter genus having a cardinal area, (marked *a* in the figure.) The presence of an area alone, however, is not *always* a sufficient distinction, since there is, in some very rare instances, an abnormally developed area in true *Productus*. The total absence of cardinal teeth and sockets, however, in the latter genus clearly separates these types. That *P. Nebrascensis* is entirely destitute of any traces of hinge teeth is well known to all in this country who have examined the interior of this shell. Figure 11 *b*, of Plate V, represents the hinge and interior of a dorsal valve of this species, and shows it to be entirely without sockets for the reception of teeth.

P. Nebrascensis is evidently very similar to *P. scabriculus* of the Old World, even to the bifurcation of the internal mesial ridge of the dorsal valve. It differs, however, in having two very distinct sets of spines, the one small and appressed, and the other stout, erect, and long. (See Fig. 11 *d*, Pl. V.)

Locality and position.—Professor Geinitz mentions this shell from divisions C and B of the Nebraska City section. I have only seen fragments of it from division C at this locality, though we have it from division B at that place, Wyoming, Bennett's Mill, &c.; and from lower positions at Rock Bluff, Plattsmouth, Bellevue, Omaha, and numerous other localities in Nebraska as well as Iowa, Illinois, Missouri, Kansas, &c. In short it is a widely distributed Coal-Measure species, from Nebraska to New Mexico, and from the Rocky Mountains eastward to West Virginia.

PRODUCTUS SYMMETRICUS, McChesney.

Pl. V, Fig. 6, *a*, *b*; and Pl. VIII, Fig. 13.

Productus symmetricus, McChesney, 1860, Descriptions New Palæozoic Fossils, p. 35; 1865, illustrations of same, Pl. I, Fig. 9, *a*, *b*; 1866, Trans. Chicago Acad. Sci., 1, p. 25, Pl. I, Fig. 9.

Shell of medium size, suborbicular, or a little wider than long; hinge line somewhat less than the greatest breadth; sides rounding regularly to the front, which is rather broadly rounded in outline; ventral valve somewhat compressed, or only moderately convex, without any traces of a mesial sinus; ears compressed but not abruptly separated from the swell of the umbo, obtusely angular or a little rounded at the extremities; beak moderately large, incurved, but not curving much within the hinge margin. Dorsal valve rather evenly, and only moderately concave, cardinal *process slender, prominent*, curved, trifid, the middle

division more prominent than the others, and emarginate at its extremity, the emargination being caused by a distinct mesial furrow that extends the entire length of the process; muscular scars somewhat convex, rather distinct in well-preserved specimens, and divided by a slender, simple mesial ridge, extending from the base of the cardinal process about three-fourths of the way to the front; whole interior, excepting the region of the muscular scars, roughened by little pustular projections which become more prominent near the anterior and anterior-lateral margins. Surface of both valves ornamented by small, rather obscure, and more or less regular concentric wrinkles, and covered by numerous small, short, rather appressed spines, which are larger on the ventral valve, where they are often connected with little, somewhat elongated tubercles.

Length of a well-developed specimen, 1.37 inches; breadth, 1.45 inches; convexity, 0.70 inch.

This shell will be readily distinguished from the last by its less convex ventral valve, without any mesial sinus, by its smaller concentric wrinkles, and particularly by having its spines consisting of a single series of small, rather depressed ones, instead of a large, stout, erect series, and another small, depressed series. Its cardinal process also differs in being trifid, and its internal ridge of the dorsal valve in being simple instead of bifid near the base of the cardinal process. The most striking differences, however, observable on comparing good specimens, consist in the differences of form mentioned, and the two sets of spines in the *Nebrascensis*.

Among European species this shell is perhaps most nearly like *P. scabriculus*, which it rather nearly resembles in most of its characters. It differs, however, in having no traces of a mesial sinus, in its finer and more distinct concentric wrinkles, and particularly in its distinctly trifid cardinal process, and the simple mesial internal ridge of its dorsal valve; that of *scabriculus* being like Owen's *Nebrascensis*, bifurcated near the base of the cardinal process.

It was probably imperfect specimens of this and the last-described species that Professor Geinitz and others have referred to *P. pustulosus* and *P. scabriculus*, from the outcrops at Bellevue and Plattsmouth; at least these two forms are more like those two foreign species, than any others known to me from the rocks of that region. They are both clearly distinct species from *P. pustulosus* and *P. scabriculus*, however.

Locality and position.—Professor Geinitz did not find this species in Professor Marcou's collections from division C, of the Nebraska City section. We found several fragments of it, however, in that bed at Nebraska, City, as well as at an apparently higher horizon 2½ miles west of there; and the distorted, but nearly entire individual, figured on Pl. VIII, Fig. 13, came from division C, at Nebraska City Landing. We also have imperfect specimens of it from division B, at that place and Bennett's Mill; also, from Peru, and from lower positions, three or four miles up Platte River, and from Bellevue, and numerous other localities in the Upper Coal-Measures of Nebraska and Kansas. It likewise occurs at the same horizon in Iowa, Missouri and Illinois, as well as in the Lower Coal-Measures of the last-mentioned State.

PRODUCTUS PUNCTATUS, Martin, sp.

Pl. II, Fig. 6, and Pl. IV, Fig. 5.

Anomites punctatus, Martin, 1809, Petref. Derb., Pl. XXXVII, Fig. 6; (not 7 and 8).
Trigonia rugosa, Parkinsen, 1811, Organic remains, Vol. III, Pl. XII, Fig. 11.
Anomites thecarius, Schloth., Nachtr. zur Petref., II, p. 63, Pl. XIV, Fig. 1.
Productus punctatus, J. Sowerby, 1822, Min. Conch., p. 22, Tab. 323; Von Buch, 1841, Abhandl. der K. Akad. der Wissensch. zu Berlin, Theil 1, Pl. II, Figs. 10, 11; de Kon., 1843, An. Foss. Carb. Belg., p. 196, Pl. X, Fig. 2; and 1847, Mong. Gen. Productus, Pl. XII, Fig. 2; de Verneuil, 1845, Russia and Ural Mts., Vol. II, p. 276, Pl. XVI, Fig. 11; Davidson, 1860, Scottish Carb. Brach., p. 42, Pl. IV, Fig. 20; and Monogr. Brit. Carb. Brach., p. 172, Pl. XLIV, Figs. 9–16.
—— *semipunctatus*, Shephard, 1838, Am. Jour. Sci., Vol. XXXIV, Fig. 9.
Producta punctata, Phillips, 1836, Geol. Yorks, p. 215, Vol. II, Pl. VIII, Fig. 10.
Leptæna sulcata, Fisher, 1837, Oryct. Mosc., Pl. XXIII, Fig. 2; (not Sowerby).
Productus concentricus, Potiez et Michaud., 1844, Galer. des Moll. du Mus. de Donái, Vol. II, p. 25, Pl. XLI, Fig. 1.
—— *tubulospinus*, McChesney, 1860, Descrip. New Pal. Foss., p. 37; also 1865, illustrations of same, Pl. I, Figs. 10 and 11.

Shell attaining a rather large size, thin, varying from rotundato-subquadrate to longitudinally subovate, being sometimes wider than long, and in other examples longer than wide, with all intermediate forms; hinge margin always shorter than the greatest breadth of the valves; anterior outline regularly rounded, or faintly sinuous in the middle. Ventral valve more or less gibbous, with a moderately distinct mesial sinus extending from near the beak to the front; beak incurved a little beyond the cardinal margin; ears rather compressed, but not distinctly defined from the swell of the umbo. Dorsal valve moderately concave with a small mesial elevation. Surface of both valves ornamented with numerous rather regular concentric ridges, increasing in size from the beaks towards the front, but becoming again smaller and more crowded in adult shells at the margin; in the ventral valve these ridges are a little prominent at the lower margin, separated from each other by smoother spaces, and support numerous small appressed spines, those of the upper row of which are larger and less crowded than the others; on internal casts, or partly exfoliated specimens, the spines are represented by small tubercles; surface of dorsal valve as in the other, excepting that the ridges are represented by little furrows.

Length of a fully developed, rather broad specimen, 2.66 inches; breadth of same, 2.50 inches; convexity about 1.10 inches.

This widely distributed species occurs in our Coal-Measures of the West, at numerous localities, as well as in the Lower Carboniferous rocks. At one time it was thought that the Coal-Measure specimens were specifically distinct, or ought to be so, from those in the lower rocks, but after a careful comparison of some fine specimens in the Illinois collection, showing the interior, cardinal process, &c., I was entirely unable to detect any specific differences from the well-known *P. punctatus*. The specimen figured by Professor McChesney (New Palæozoic Fossils, Pl. I, Fig. 11), has the cardinal process incomplete, and shows the muscular impressions imperfectly, without any traces of the reniform markings; but I have seen these, as stated above, in others in a better state of preservation from the Coal-Measures of Illinois, as they are represented by Mr. Davidson, in his beautiful figures of *P. punctatus*.

Locality and position.—Division B of Nebraska City section, at that place, Bennett's Mill, and Wyoming, and at, possibly, a higher horizon in a shaft near Nebraska City; also at Rock Bluff, Plattsmouth, and Bellevue; and numerous places in the Upper Coal-Measures of Illinois, Iowa, Missouri, Nebraska, Kansas, &c. It likewise occurs in the Lower Coal-Measures, and *even in the Lower Carboniferous rocks of Missouri, Iowa, Illinois, &c.*

Genus CHONETES, Fischer.

CHONETES VERNEUILIANA, N. & P.

Pl. I, Fig. 10 *a*, *b*.

Chonetes Verneuiliana, Norwood & Pratten, 1854, Jour. Acad. Nat. Sci. Philad., Vol. III, p. 26, Pl. II, Fig. 6, *a*, *b*, *c*; Shumard, 1855, Missouri Geol. Report, p. 216.

Shell rather small, varying from transversely sub-semicircular, to sub-oblong; hinge line more or less extended beyond the breadth of the valves at any other point; sometimes greatly produced. Ventral valve very convex, with a deep rounded mesial sinus, starting near the beak and deepening and widening rapidly to the anterior margin, to which it imparts a distinctly sinuos outline, thus dividing the gibbous part of the valve into two prominent, rounded lobes or diverging ridges, separated from the ear on each side by a broad rounded depression; ears more or less angular, sometimes extended and acutely pointed, slightly arching, and a little reflexed; beak rather prominent, and incurved; area moderately developed and common to both valves, but widest in the ventral; foramen wide; cardinal margin provided with four oblique spines on each side of the beak. Dorsal valve following rather nearly the curve of the other, and provided with a mesial ridge corresponding to the sinus of the other valve. Surface of each valve, ornamented with about 100 fine bifurcating, radiating striæ, and sometimes near the front, by a few marks of growth.

Length of a medium-sized specimen, 0.27 inch; breadth, 0.40 inch; convexity about 0.12 inch.

This species is remarkable for its convex ventral valve, with its deep mesial sinus, which imparts to it a peculiar bilobate appearance. I know of no species with which it is liable to be confounded.

Locality and position.—Plattsmouth, and various other localities in the Upper Coal-Measures of Nebraska, as well as Kansas, Iowa, Missouri, Illinois, &c. The remarkably extended specimen from which Fig. 10 *b*, of Plate I, was drawn, come from near the same horizon as the Plattsmouth outcrop, four miles up the Platte.

CHONETES GRANULIFERA, Owen.

Pl. IV, Fig. 9; Pl. VI, Fig. 10; Pl. VIII, 7.

Chonetes granulifera, Owen, 1855, Geol. Rep. Minn., Iowa, and Wisconsin, p. 583, Tab. V, Fig 12.

——— *mucronata*, Meek & Hayden, 1858, Proceed. Acad. Nat. Sci. Philad., p. 262; Paleont. Upp. Mo., p. 22, Pl. I., Fig 5, *a*, *b*, *c*, *d*, *e*; Geinitz, 1866, Carb. und Dyas, p. 58, Tab. IV, Figs. 12, 13, and 14; not *Chonetes mucronata* (=*Strophomena mucronata*, Conr., 1843).

Shell attaining a rather large size, semicircular in outline, having its greatest breadth on the hinge line, which often terminates in extended mucronate ears. Larger or ventral valve moderately convex, the greatest convexity being in the central region, or rather on each side of it, as there is usually a broad, shallow, mesial depression; ears and lateral regions compressed; front somewhat straightened along the middle; beak small, rather compressed, a little arched, and scarcely projecting beyond the cardinal margin, which is provided with from seven to about eleven oblique spines on each side of the beak; area rather narrow, ranging nearly parallel to the general plane of the valves, its fissure broad, partly closed above by an arching deltidium; hinge teeth well developed, compressed, and minutely striated; interior with impressions of cardinal muscles subovate, diverging, attenuate above;

adductor muscular scars small, narrow-subelliptical; mesial ridge prominent near the beak, much lower, and rarely extending forward to the central region; most of the interior occupied by granules, which are largest and most crowded on a narrow space around near the front and lateral margins; but around the immediate margin they are much smaller, and arranged in distinct radiating rows.

Dorsal or smaller valve, following nearly the curve of the other, the beak and central regions being concave, and the ears flat; area well developed, but narrower than in the other valve; bifid cardinal process and mesial prominence, nearly or quite closing the fissure of the other valve. From the base of this process, there are extending, on the inner side of the valve, five radiating ridges, two of which pass obliquely outward, forming the inner margins of the dental sockets, while a third mesial one extends at right angles to the hinge, a little more than half-way to the front; the other two are much shorter, oblique, and occupy intermediate positions between the middle and the two latter ones; granules of the interior as in the other valve.

Surface of both valves ornamented with a few subimbricating marks of growth, crossed by very fine, obscure, regularly and closely arranged radiating striæ, of which about one hundred and fifty may be counted around the free border of a large individual, where eight or nine of them may be counted in the space of one line.

Length of a large specimen, 0.62 inch; breadth on hinge line, 1.13 inches.

I am now, after seeing specimens from various localities along the Missouri River, nearly satisfied that this must be the same shell described by Dr. Owen, under the name *C. granulifera*. His figures and description are unfortunately so imperfect as to leave this question somewhat doubtful. He gives four figures, none of which are near so extended on the hinge, nor so mucronate at the lateral extremities as in well-developed specimens of the form for which we proposed the name *C. mucronata*, while they give the appearance of much coarser surface markings. Judging from the localities at which he obtained his typical specimens, however, and from numerous collections before me from the same and other localities, I can scarcely doubt that he must have founded his species on the same shell to which we afterwards gave the name *C. mucronata*.

Chonetes Smithii, of Norwood & Pratten, is a form with which this shell should be compared, though the form here described attains a much larger size, and is more compressed, as well as more extended on the hinge. The latter character, however, can scarcely be regarded as a specific distinction in this genus, as may be seen by the figures of *C. Verneuiliana*, given on Plate I.

Locality and position.—Division C, of the Nebraska City section; also in Division B, at the same place, and at Wyoming and Bennett's Mill; likewise at lower horizons at Plattsmouth, Bellevue, Omaha, and at numerous other localities in Nebraska, Kansas, Missouri, Iowa, &c., it being a very common shell in the Coal-Measures of that region. Specimens of a somewhat smaller size, but otherwise undistinguishable, also occur in the Coal-Measures of Illinois.

CHONETES GLABRA, Geinitz.

Pl. IV, Fig. 10; Pl. VIII, Fig. 8 *a*, *b*.

Chonetes glabra, Geinitz, 1866, Carb. und Dyas in Neb., p. 60, Pl. IV, Figs. 15–18.

Shell thin; transversely sub-semicircular, the length being more than half the breadth; *hinge line a little longer* than the greatest breadth of the

valves, at any point farther forward; lateral extremities abruptly pointed and sometimes slightly recurved; anterior and anterior-lateral margins, forming a semi-circular curve in outline, excepting that the former is generally faintly sinuous in the middle; lateral margins curving abruptly outward just before intersecting the hinge extremities. Ventral or larger valve moderately convex, the most gibbous part being in the form of two broad, rounded, undefined prominences, which diverge from the beaks to the anterior lateral regions, leaving a broad, rounded, rather deep mesial sinus between them, extending nearly to the beak, but widening and deepening rather rapidly to the front; outside of these prominences, the posterior lateral regions are more or less compressed; beak small, compressed, slightly arched, and scarcely projecting beyond the cardinal margin; area narrow, inclined obliquely backward; its fissure small, nearly semi-circular and partly closed by the cardinal process of the other valve; cardinal margin armed on each side of the beak by four or five slender, moderately long, oblique spines, with sometimes remains of one or two much smaller rudimentary additional ones near the beak; cardinal teeth compressed, their longer diameter ranging nearly parallel to the hinge line—as seen under a strong magnifier, finely striated on the outside, at right angles to their length. Interior, excepting in the region of the muscular impressions, with numerous rather distinct granules, arranged in radiating rows—immediately within the fissure, provided with a short, rather prominent, compressed ridge ranging at right angles to the hinge; muscular impressions very obscure.

Dorsal or concave valve, following nearly the curve of the other; area of about the same size as in the dorsal valve, inclined forward from the hinge; cardinal process small, not very prominent, and as seen on the outer side somewhat trilobate, the middle lobe or ridge being divided by a linear sulcus; socket ridges very oblique; interior granulated as in the other valve. A very small, obscure linear ridge occupies the middle of the valve, without, however, extending up to the hinge; muscular impressions unknown.

Surface of both valves nearly smooth, but showing obscure concentric marks of growth. In some conditions of weathering, there is a faint appearance of radiating markings, but this is due rather to the structure of the shell, and not to proper external lines. When a single one of the thin valves is cleaned and examined by the aid of a good magnifier and a strong transmitted light, large, very scattering punctures or pores are seen arranged in quincunx, and passing obliquely through the shell. These appear to have been connected with minute tubular spines, arranged over the whole surface, during the life of the animal. At any rate, in one specimen, of which Fig. 8 *b*, Plate VIII, is a representation enlarged two diameters, there are numerous little projecting points having the appearance of minute spine bases projecting through a film of shale on the surface. They must, however, be extremely fragile and readily removed, as no traces of them are to be seen on any of the numerous other specimens in the collection.

Locality and position.—Division C of the Nebraska City section, where it is very abundant, and found in a fine state of preservation. It also occurs at that locality, though much less abundantly, in division B. It is likewise found common at a much lower horizon in the Coal-Measures at Atchison, Kansas. It is a remarkable fact that in a collection sent by Mr. Dall, from Russian America, there is a small rolled erratic mass of very hard siliceous rock, picked up on the shores of Youkon River, containing a *Chonetes* apparently agreeing with this in every respect.

Genus ORTHIS, Dalman.

ORTHIS CARBONARIA, Swallow.

Pl. I, Fig. 8, *a*, *b*, *c*.

Orthis carbonaria, Swallow, 1858, Trans. St. Louis Acad. Sci., 1, p. 218.
? —— *Pecosii*, Marcou, 1858, Geol. N. Am., p. 48, Pl. VI, Fig. 14, *a*, *b*.
? —— (sp. undt.), Meek, 1864, Paleontology of California, Vol. I, p. 10, Pl. II, Fig. 5, *a*, *b*, *c*.

Shell small, suborbicular, slightly wider than long, moderately convex in adult specimens; lateral margins rounded, or, in some examples, faintly straightened posteriorly; front more broadly rounded, but usually very slightly sinuous in the middle; valves nearly equally convex; hinge line very short, or only equaling about half the breadth of the valves. Ventral valve usually most convex in the umbonal region, sometimes a little flattened anteriorly, so as to give the shell slightly the form usually called "resupinate," though in gibbous specimens this character is nearly obsolete; beak moderately prominent, rather pointed and arched; area small, well defined, and arching with the beak; foramen narrow. Dorsal valve usually most convex between the middle and the beak, which is small, and nearly as prominent and arched as that of the other valve, generally with a shallow sinus extending from the middle to the front; area well developed, but smaller than in the other valve, arched and divided by a proportionally shorter foramen. Surface of both valves ornamented with concentric marks of growth and numerous fine radiating crowded striæ, which increase mainly by intercalation, and, as in many other species of the genus, show occasional perforations toward the front, apparently left by the removal of very small tubular spines.

Length of a well-developed gibbous specimen, rather above a medium size, 0.38 inch; breadth, 0.43 inch; convexity, 0.27 inch. Largest specimen about 0.44 inch in length, and 0.51 inch in breadth.

This little shell resembles so nearly, in form and surface characters, some varieties of *O. resupinata* and *O. Michelini*, that scarcely any one familiar with those shells, if shown a few of these, would hesitate to pronounce them young examples of one or the other, or both of those species. Still, from its uniform much smaller size, even at widely distant localities, and in beds of various lithological characters, where not associated with any similar larger shell, leads me to think it must be distinct, and that our specimens really represent the adult size. In addition to their smaller size, a careful comparison also shows that they certainly do present some appreciable and constant differences. For instance, *O. carbonaria* has its beaks more nearly equal than either *O. resupinata* or *O. Michelini*, and more prominent, particularly that of its dorsal valve, which is also more pointed. It is also generally proportionally more thickened within on each side of the rostral cavity in the ventral valve.

Locality and position.—The specimen figured was found, with others (some of which are less convex), at Rock Bluff, in Upper Coal-Measure beds, referred by Professor Marcou to the Lower Permian, (Dyas). We also have some crushed and distorted specimens of apparently the same shell from division B at Nebraska City, referred by Professors Marcou and Geinitz to the lower part of the Upper Permian. It likewise occurs at various lower horizons in the Upper Coal-Measures in Iowa, Nebraska, Kansas, Illinois, &c.; while Professor Swallow's typical specimens were from the Middle Coal-Measures at Lexington, Missouri.

Genus HEMIPRONITES, Pander.

HEMIPRONITES CRASSUS, M. and H.

Pl. V, Fig. 10, *a*, *b*, *c*; and Pl. VIII, Fig. 1.

Orthisina crassa, Meek and Hayden, 1858, Proceed. Acad. Nat. Sci., Philad., p. 260.
Orthis Lasallensis, McChesney, 1860, New Paleozoic Fossils, p. 32; and 1865, illustrations of same, Pl. I, Fig. 6, *a*, *b*.
——— *Richmondi*, McChesney, *ib.*, Fig. 5, *a*, *b*, *c*.
Hemipronites crassus, Meek and Hayden, 1864, Paleont. Upper Missouri, p. 26, Pl. I, Fig. 7, *a*, *b*, *c*, *d*.
——— *Lasallensis*, and *H. crassus*, McChesney, 1867, Trans. Chicago Acad. Sci., Vol. I, p. 28, Pl. I. Figs. 5 and 6.
Compare *Orthis Keokuk* and *O. robusta*, Hall, 1858, Iowa Geol. Report, Vol. I, Part 2, p. 640, Pl. XIX, Fig. 5, *a*, *b*, and p. 713, Pl. XXVIII, Fig. 5, *a*, *b*, *c*.

Shell varying from semi-circular to truncato-subcircular, or transversely suboblong, generally wider than long, varying from compressed to distinctly convex; hinge margin equaling, or shorter than, the greatest breadth of the valves, rectangular or sometimes more or rather less than rectangular at the extremities; anterior outline forming a more or less regular semi-circular curve. Dorsal valve always convex, sometimes very distinctly so, the greatest convexity being near the middle; beak not distinct from the cardinal margin. Ventral valve varying in convexity at the umbo, sometimes very prominent, and occasionally distorted there; less convex, flattened, or not unfrequently a little concave around near the front; area varying in height in proportion to the elevation of the beak, and either flat or with the beak a little arched, usually rather distinctly striated; its closed fissure varying in the proportions of height and breadth, with the greater or less elevation of the beak; interior always provided with a prominent mesial septum extending from the beak forward to near the middle of the valve. Surface of both valves marked by numerous strong, raised radiating striæ, of unequal size, there being generally one or several smaller ones between each two of the larger; crossing the whole are also numerous fine, regular concentric striæ, more or less defined both between and upon the radiating striæ, to which latter they impart a neatly crenate appearance.

After proposing the name *H. crassus* for this species, I was led to think it most probably only a variety of the well-known widely distributed European *H. crenistria*, which it certainly very closely resembles in external characters. On sending specimens showing the interior of the valves from the original locality, however, to Mr. Davidson, he wrote back that he could not think it properly belongs to that species, because among all the specimens of that form he had examined he had never seen one showing the peculiar mesial septum always so strongly developed in the interior of the ventral valve of this shell. I have no doubt in regard to its identity with *Orthis Lasallensis* and *O. Richmondi*, of McChesney, and I suspect the same species has been described by Professor Hall in the Iowa Report under the names *Orthis Keokuk* and *O. robusta*, particularly the former, which seems to have the same mesial septum within the ventral valve, and agrees nearly in other characters excepting in its larger size.

Locality and position.—Divisions B and C of the Nebraska City section, and from apparently above the latter horizon 1¾ and 2¾ miles west of there; and again from bed B at Bennett's Mill and Wyoming; also at lower horizons in the Upper Coal-Measures at Cedar Bluff, Rock Bluff, Plattsmouth, Bellevue, and Omaha. It likewise occurs at Peru, Rulo, and Brownville, as well as at numerous other localities and positions in the

Coal-Measures of Nebraska, Kansas, Iowa, Missouri, and Illinois; and I have recently identified it among specimens collected by Professor J. J. Stevenson from the horizon of the Chester limestone in West Virginia.

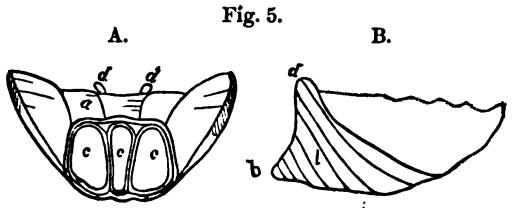
Genus MEEKELLA, White and St. John.

MEEKELLA STRIATO-COSTATA, Cox, sp.

Pl. V, Fig. 12, *a*, *b*, *c*.

Plicatula striato-costata, Cox, 1857, Owen's Geol. Report, Ky., Vol. III, p. 568, Pl. VIII, Fig. 7.
Orthis striato-costata, Geinitz, 1866, Carb. und Dyas in Neb., p. 48, Tab. III, Figs. 22–24.
Meekella striato-costata, White and St. John, 1867, Trans. Chicago Acad. Sci., Vol. 1, p. 120 and 121, Figs. 4, 5, and 6.
Compare *Streptorhynchus pectiniformis*, Davidson, 1863, Liege, Brach., Pal. l'Inde, Pl. X, Fig. 17.

Fig. 5.



Meekella striato-costata.

A. Showing a transverse section of the beak of the ventral valve, (*a*) being the remaining portion of the cardinal area, (*d d*,) the dental processes, and (*c c c*) the tree-chambers into which the interior is divided by the two intervening septa.
B. Showing a longitudinal section of the same valve, (*l*) being the side and outline of one of the septa or dental laminæ, (*b*) the point of the beak, and (*d*) the dental process. (After Dr. White's and Professor St. John's figures.

Fig. 6.

Meekella striato-costata.

A posterior view of dorsal valve, showing above the remarkable cardinal process, with its broken alate part restored in outline; from a specimen borrowed from Dr. White.

Shell trigonal-subglobose, becoming very convex with age, generally a little longer than wide; hinge line very much shorter than the breadth of the valves. Dorsal valve convex, the greatest prominence near the umbo, thence rounding over to the front, being usually somewhat flattened over the central and anterior regions, but without any mesial sinus; beak strongly incurved and with its most prominent part sometimes projecting a little beyond the hinge line, but in others flattened, and with its immediate apex nearly always terminating at the margin of the hinge; posterior lateral margins laterally compressed and converging toward the umbo at nearly a right angle; surface ornamented by about ten to thirteen large radiating, more or less angular, simple or rarely bifurcating plica-

tions, which are themselves (as well as the furrows between) marked by fine but distinct radiating striæ, which, toward the front, instead of continuing parallel to the furrows and plications, converge forward on each side of the latter so as to intersect along the crests of the same at acute angles; crossing all of these, there are usually near the front and lateral margins, a few strong zigzag marks of growth. Ventral valve more convex than the other, the greatest convexity being at or near the beak, which is elevated and usually more or less distorted, being sometimes twisted to one side, and in other examples straight or somewhat arched backward; cardinal area narrow transversely, but proportionally high, being often distinctly higher than wide but well-defined, and usually finely striated transversely and vertically, either flat or more or less arched backward; false deltidium closing the fissure, narrow and provided with a slender, rounded, prominent mesial ridge extending to the apex of the beak; surface as in the other valve.

Length of a medium-sized well-developed adult specimen, 1.06 inches; convexity of same, 0.97 inch; breadth, 1.12 inches.

Individuals of this shell vary much in size and form, and especially in the elevation of the beak and area of the ventral valve. As in the allied genus *Hemipronites* (=*Streptorhynchus*), the beak of its ventral valve is often considerably distorted, and occasionally with its immediate apex truncated as if from adhesion by the substance of the young shell. In most of its external characters it is *very* closely allied to an East Indian form described by Mr. Davidson under the name *Streptorhynchus pectiniformis*. (See Fig. 16 of our Pl. V.) Professor Geinitz and Mr. Davidson (the latter after a direct comparison of specimens) think there are no well-grounded specific differences by which these shells can be distinguished; and I confess, after comparing a specimen of the Indian form sent by Mr. Davidson to Dr. White, and along with it a fine series of the western shell from Iowa, kindly loaned to me for comparison by the latter gentleman, that one would scarcely suspect any specific difference to exist between these shells if found together at the same locality and associated in the same beds. Without undertaking to decide this question with but a single specimen of the Indian form for comparison, I would merely remark that both on Mr. Davidson's figure and on the specimen before me of the latter, the radiating striæ are perceptibly coarser than on our shell, and not converging to the crests of the plications, as may be seen by comparing the figures of the two on Plate V. In addition to this, a transverse section across the beak of the ventral valve of the Indian specimen quite unexpectedly reveals no traces of the strongly developed dental laminæ of the American shell. These, however, may have been broken out by some accident; otherwise there would seem to be even a generic difference.

Dr. White and Professor St. John have, as I think, very properly separated the form under consideration generically from *Hemipronites* (=*Streptorhynchus*), on account of its dental supports in the ventral valve instead of merely converging to the apex of the beak under the area, having the form of two strongly-developed laminæ attached to the bottom of the valve and produced forward with slight divergence nearly to the middle of the same. The cardinal process of the other valve is also much more prominent than that of *Hemipronites*. and very differently formed, as may be seen by the annexed cut. These characters, and the differences in the general physiognomy of the two types, seem to me to distinguish them generically. There are also some large scattering punctures about the beak of the ventral valve of the form under consideration that I have never seen in *Hemipronites*. It, therefore, ap-

pears to bear the same relations to the latter that *Syntrilasma* does to *Orthis*.

Locality and position.—This shell was first described by Professor Cox from the Coal-Measures of Kentucky. It also occurs at various horizons in the Middle and Upper Coal-Measures of Iowa, Missouri, and Illinois. The specimen we have figured is from division B, at Nebraska City, and we found it at lower horizons at Bellevue and Plattsmouth, and at higher positions at Otoe City, Aspinwall, &c., in Nebraska. I have never seen it from any locality east of Illinois, nor anywhere in the Lower Coal-Measures.

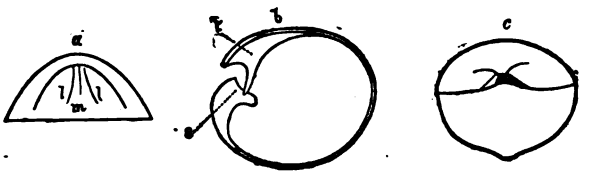
Genus SYNTRILASMA, M. & W.

SYNTRILASMA HEMIPLICATA, Hall, sp.

Pl. VI, Fig. 1, *a*, *b*; and Pl. VIII, Fig. 12 *a*, *b*.

Spirifer hemiplicatus, Hall, 1852, Stansbury's Salt Lake Report, p. 409, Pl. IV, Fig. 3, *a*, *b*,
Syntrilasma hemiplicata, Meek & Worthen, 1866, Report Geol. Survey, Ill., Vol. I, p. 323. Fig. 36, and p. 324, Fig. 37.
Rhynchonella angulata, Geinitz, 1866, Carb. und Dyas, p. 37, Tab. III, Figs. 1–4; (not *R.* [*Anomia*] *angulata*, Linnæus, 1767).

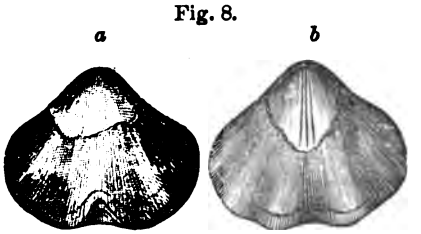
Fig. 7.



Syntrilasma hemiplicata.

a. A transverse section of a ventral valve, showing the three laminæ (*l*, *m*, *l*) of the interior.
b. A longitudinal section of the two valves united, showing the side of one of the dental laminæ (*l*) and the side of one of the socket-plates, (*s*).
c. A cardinal view, showing the small area and the triangular foramen.

Fig. 8.



Syntrilasma hemiplicata.

a. Shows a dorsal view with a portion of the shell removed so as to expose in the cast the diverging socket plates.
b. A similar view of the ventral valve, showing the three closely approximated parallel plates within.

Shell in young examples only moderately convex, and having all the external appearances of a true *Orthis*; in adult specimens, often globose, or even more convex than long or wide. Hinge line very short, or not more than one-third the greatest breadth of the valves, and, owing to the gibbosity of the shell, imparting little or no angularity to the outline of

the lateral slopes. Dorsal valve more convex than the other, and very strongly arched, particularly in mature shells; umbonal region gibbous, and often, in adult examples, projecting somewhat beyond the beak of the other valve; beak strongly incurved, so as to bring its apex under the beak, and nearly against the area of the other valve; area rather narrow and distinctly incurved with the beak.

Ventral valve convex; beak only moderately prominent and arched, or more or less incurved; area triangular, small, about one-third as high as wide, and moderately well defined; its triangular foramen scarcely as wide as high. Surface of both valves ornamented with rather fine, regular, crowded radiating striæ, and a few very large, rounded, or more or less angular, radiating plications, which latter are never defined on the umbones, but occupy the anterior half, and become more prominent toward the front, where they often terminate in deeply interlocking angular marginal projections. Of these plications there are two—rarely three—on each side of the slightly larger and more prominent one forming the mesial fold on the dorsal valve, while on the ventral valve there are three—rarely four—on each side of the mesial sinus; a few zigzag marks of growth also traverse the anterior and lateral margins of the valves, parallel to their deeply-notched edges.

Length of a medium-sized adult specimen, 0.72 inch; breadth, 0.74 inch; convexity, 0.75 inch. Radiating striæ numbering twelve to fifteen in 0.10 inch.

This interesting and peculiar shell was, by an oversight, referred by Professor Geinitz to *Rhynchonella angulata*, Linn. sp. Although it resembles that species somewhat in general external appearances, it is really very widely removed from it by its generic and even family characters, being a distinctly punctate shell, with a well-defined, though small, cardinal area, divided by an open triangular fissure, and having in the other valve a cardinal process exactly as we see in *Orthis*.* It differs generically, however, from the latter, in having the dental laminæ very closely approximated, prominent, and, with a third mesial plate, continued nearly parallel to each other far forward.

Specifically, it is very closely allied to a South American Carboniferous shell referred by Mr. Salter in the Quart. Jour. Geol. Soc. Lond., XVII, p. 64, Pl. IV, Fig. 3, to *Terebratula Andii*, d'Orbigny. I have also, through the politeness of Colonel Romanowski, of the mining engineers' department of Russia, some imperfect specimens from the Mountain limestone of Rjasan, Russia, with the name *Spirifer Lamarckii*, Fischer, attached, that I believe to belong to the species under consideration. I have not seen the original figures and description of Fischer's species, but if correctly represented by Murchison, de Verneuil and v. Keyserling in the Geology of Russia, I should think it distinct, specifically, from the form sent by Colonel Romanowski. At any rate, I can scarcely doubt that Fischer's species ought to be called *Syntrilasma Lamarckii*, as it resembles our typical species apparently too nearly to belong to any other genus.

Locality and position.—Divisions B and C of the Nebraska City section; also at the former horizon at Wyoming, Bennett's Mill, &c., and at numerous lower horizons in the Coal-Measures of Illinois, Iowa, Nebraska, Kansas, Missouri, &c.

* Mr. Davidson, to whom I sent specimens of this shell, writes that he thinks it a good genus.

Genus RHYNCHONELLA, Fischer.

RHYNCHONELLA OSAGENSIS, Swallow.

Pl. I, Fig. 9, *a*, *b*, and Pl. VI, Fig. 2, *a*, *b*.

Rhynchonella (*Camarophoria*) *Osagensis*, Swallow, 1858, Trans. St. Louis Acad., S. 1, p. 219.
Terebratula Cta, Marcou, 1858, Geol. N. Am., p. 51, Pl. VI, Fig. 12, *a*, *b*, *c*.
? *Rhynchonella*, sp., Salter, 1851, Jour. Geol. Soc. London, Vol. XVII, p. 64, Fig. 5, *a*. *b*.
Camarophoria globulina, Geinitz, 1855, Carb. und Dyas in Neb., p. 38, Tab. III, Fig. 5; (not *C. globulina*, Phillips, sp., 1834).

Shell small, more or less variable in form, often subtrigonal, generally wider than long, more or less gibbous; front truncated, or sometimes sinuous in outline; anterior lateral margins rounded in outline; posterior lateral margins convex, or nearly straight and converging to the beaks at an angle of from about 90° to 120°. Dorsal valve more convex than the other, greatest convexity near the middle or between it and the front, which has a broad, rather deep, marginal sinus, for the reception of a corresponding projection of the front of the other valve; mesial fold somewhat flattened, but slightly prominent, and rarely traceable back of the middle of the valve; generally composed of three, but sometimes of four—rarely more—plications; sides rounding down rapidly on each side of the mesial fold, and each occupied by about three or four simple plications; beak curving strongly beneath that of the other valve; interior with a faint linear mesial ridge, on each side of which is a raised curved line inclosing an ovate space, occupied by the adductor muscular impressions. Ventral valve distinctly less convex than the other, with a broad, shallow, short sinus occupied by about two or three short plications; anterior lateral margins on each side of the sinus, with from two to four simple plications; beak moderately prominent, and more or less arched, rather pointed; foramen small.

Length of a medium sized specimen, 0.40 inch; breadth, 0.45 inch; convexity, 0.32 inch.

Like most other species of the genus, this varies considerably in form; some individuals being proportionally wider and more gibbous than others. It also varies in the number of its plications, from six or seven to about twelve, or rarely thirteen or fourteen to each valve. In a majority of instances there are only two plications in the mesial sinus and three on the fold. Some specimens have more, though I have not seen any I could confidently refer to this species, with as many as six plications in the sinus, as stated by Professor Swallow to be sometimes the case.

As remarked by Professor Swallow, some individuals of this species resemble *Camarophoria Schlotheimi*, or at least certain forms of that species, quite closely. Professor Geinitz has even referred it to *Camarophoria globulina*, Phillips, a shell by some believed to be only a variety of *C. Schlotheimi*; but as I have elsewhere stated, it is certainly distinct from those forms, because it is not a *Camarophoria* at all, but true *Rhynchonella*. This I have ascertained both by internal casts and by sections made across the beak of the ventral valve, of specimens from various localities.

As we obtained no good specimens from division C, at Nebraska City, I have copied on Pl. VIII the figure given by Professor Geinitz. Fig. 2 *a*, *b*, Pl. VI, represents another specimen from division B of the same section, two and a half miles west of Nebraska City; while Fig. 9, *a*, *b*, Pl. 1, represent an internal cast from Rock Bluff, on the Missouri, at a lower horizon in the Coal-Measures. From these figures, particularly Fig. 9 *b*, it may be at *once seen that this* shell is a true *Rhynchonella*, and

not a *Camarophoria*, as it shows no traces whatever of the rostral chamber characteristic of that genus. I have been unable to find a figure of *Camarophoria globulina*, showing the interior, but have copied for comparison from Professor King's work on the Permian Fossils of England, a figure of an internal cast of the closely-allied form *C. Schlotheimi* (Fig. 15, Pl. I), from which students will at once see by comparison with Fig. 9 *b*, of the same Plate, the generic differences between these shells; (*a*) of Fig. 15, being the cast of the rostral chamber, which is separated by a wall from the other part of the interior; while in Fig. 9 *b*, the cast of the rostral cavity is a mere protuberance, without any traces of the deep slits left by the walls of a chamber.

Locality and position.—This species occurs in divisions C and B, at Nebraska City. It ranges through a great thickness of our Coal-Measures, and is found at numerous localities in Iowa, Missouri, Nebraska, Kansas, &c. I have also seen specimens of it from the Upper, Middle, and Lower Coal-Measures of Illinois; and it is probably the same shell that was figured by Mr. Salter in 1861, among Professor Forbes's collections from the Andes, South America.

Genus ATHYRIS, McCoy.

ATHYRIS SUBTILITA, Hall, sp.

Pl. I, Fig. 12; Pl. V, Fig. 8, and Pl. VIII, Fig. 4.

? *Terebratula argentea*, Shepard, 1838, Am. Jour. Sci., XXXIV, p. 152.
? *Spirifer Roissyi* (*Terebratula Peruviana*, on plate), d'Orbigny, 1847, Palæont. del'Amer. Merid., p. 46, Pl. III, Fig. 17–19.
Terebratula subtilita, Hall, 1852, Stansbury's Grt. Salt Lake Report, p. 409, Pl. IV (by error in text II), Fig. 1 *a*, *b*, and 2 *a*, *b*; Swallow, 1855, Missouri Geol. Report, p. 79, 80, 81, &c.; Shumard, ib. p. 216; Schiel, 1855, Pacif. R. R. Rep., II, p. 108, Pl. 1, Fig. 2; Hall, 1856, Pacif. R. R. Rep., Vol. III, p. 101, Pl. 2, Fig. 4.
———? *subtilita*, Davidson, 1857, Monogr. Brit. Carb. Brach., p. 18, Pl. 1, Fig. 21, 22.
Spirigera subtilita, Meek and Hayden, 1859, Proceed. Acad. Nat. Sci., Philad., p. 20, &c.
Athyris subtilita, Newberry, 1861, Ives's Colorado Report, p. 126; Davidson, 1863, Fossils of S. India, Pl. IX, Fig. 7.
———*subtilita*, Salter, 1861, Quart. Jour. Geol. Soci., Lond., XVII, Pl. IV, Fig. 4 *a*, *b*.

Shell ovoid, being usually widest a little in advance of the middle, and nearly always somewhat longer than wide, moderately convex, becoming rather gibbous with age. Ventral valve, usually a little more convex than the other, its greatest convexity being generally behind the middle; beak prominent, rounded and distinctly incurved upon that of the other valve; foramen round, of moderate size, and truncating the immediate apex of the beak; mesial sinus, absent or very shallow, in young or compressed individuals, but well defined, and round, flattened, or angular in adult gibbous specimens, in which it rapidly increases in size, from near the middle to the front, where it produces a more or less prominent marginal projection, fitting into a corresponding sinuosity in the margin of the opposite valve. Dorsal valve moderately convex, the greatest convexity in small or compressed specimens often near the middle or between it and the umbo, but in large, gibbous individuals, with a well defined, prominent mesial fold, sometimes near the front; beak rather distinctly incurved under that of the opposite valve. Surface of both valves nearly smooth, or with mere lines of growth, in young shells, but in large or mature specimens with well defined, imbricating marks of growth on the anterior half; exfoliated surfaces also show, under a magnifier, traces of obscure radiating striæ.

Length of a well-developed, medium-sized specimen, 0.95 inch, breadth, 0.81 inch; convexity, 0.56 inch. Very large specimens sometimes meas-

ure as much as 1.54 inches in length. At some localities, however, the average length of evidently adult examples is only about 0.60 inch.

As may be seen by the above measurements, this shell varies considerably in form, as well as in size. Young individuals, or those that have had their growth arrested by unfavorable circumstances, are always more compressed and proportionally rounder in outline, while they show no traces of a mesial fold or sinus, and have less distinct marks of growth. Notwithstanding these differences of form, proportions, &c., there is something in the general physiognomy of this shell that enables one, once familiar with its appearance, to recognize it without difficulty.

It is quite probable that we may have to adopt the name *Athyris* or *Spirigera** *argentea*, for this species, since Shepard, in 1838, figured under the name *Terebratula argentea*, a shell from the Upper Coal-Measures of La Salle, Illinois, agreeing more nearly with this than with any other known in these rocks, while this species is very common there. If his type can be found, and should prove to be another form, then it will become a question whether we will not have to call it *Athyris* or *Spirigera Peruviana*, because d'Orbigny figured a South American shell in 1847, under the name *Terebratula Peruviana*, almost exactly like this, and believed by Mr. Salter and others to be the same.

Locality and position.—We did not find this species in division C of the Nebraska City section, and have therefore copied Professor Geinitz's figure of a specimen from that horizon. We found it, however, at apparently a higher position, one and three-fourths and two and three-fourths miles west of there, and at the horizon of B at Bennett's Mill, Wyoming, &c. It is also common at lower positions at Cedar and Rock Bluffs, Plattsmouth, Bellevue, and Omaha; and it occurs at almost all horizons in the Coal-Measures, of Illinois, Missouri, Iowa, West Virginia, and Ohio; also, at Pecos Villages, New Mexico; and less abundantly in the Coal-Measures and up through the Permo-Carboniferous beds into the Permian, in Kansas. In England and India it has been identified in Lower Carboniferous rocks; but in this country, unless *A. subquadrata* of Hall, is only a variety of this species, it has not been found below the Coal-Measures.

Genus RETZIA, King.

RETZIA PUNCTULIFERA, Shumard.

Pl. I, Fig. 13; and Pl. V, Fig. 7.

Retzia punctulifera, Shumard, 1858, Trans. St. Louis, Acad. Sci., Vol. I, p. 220.
Terebratula Mormonii, Marcou, 1858, Geol. North Am., p. 51, Pl. VI, Fig. 11.
Retzia Mormonii, Meek and Hayden, 1859, Proceed. Acad. Nat. Sci. Philad., p. 27; Geinitz, 1866, Carb. und Dyas in Neb., p. 39, Tab. III, Fig. 6.
Retzia subglobosa, McChesney, 1860, Descrip. New Pal. Fossils, p. 45; and Pl. I, Fig. 1, illustrations of same, 1865.

Shell small, ovate; in mature specimens, gibbous; hinge line short, or scarcely extended enough to show distinctly the little ears at the extremities. Ventral valve more convex than the other, the greatest convexity being between the middle and the umbo, which is prominent, rounded, more or less strongly arched, and provided with a moderately large circular foramen; area well defined, triangular, and arching with the beak. Dorsal valve most convex near the middle; beak extending

* It is an unsettled question, whether the name *Spirigera* or *Athyris* should be retained for this genus. *Athyris* has priority of date, but is very objectionable, because it implies a plain *contradiction of fact, the shell being* provided with a distinct foramen.

a little beyond the hinge margin, and distinctly incurved. Surface of each valve ornamented by fourteen or fifteen (very rarely sixteen to seventeen) simple, rather prominent, radiating costæ, one or two of which are sometimes slightly more depressed than the others, near the front of the ventral valve, so as to cause some appearance of an obscure mesial sinus, but without producing any corresponding mesial elevation on the other valve, or visibly interrupting the general straightness of the uniting margins of the two valves; lines of growth obscure; punctures visible under a good pocket lens, and very regularly disposed.

Length of a well-developed, rather gibbous specimen, 0.35 inch; breadth, 0.30 inch; convexity, 0.25 inch.

If the shells generally included in the genus *Retzia*, but differing from Professor King's type of that genus (*R. Adrieni*) in the possession of a small cardinal area, are, as has been proposed,* to be considered generically distinct, the name of this species would become *Eumetria punctulifera*, as it has the small cardinal area characterizing that group.

Specifically, this form is related to *Retzia radialis*, Phillips, sp., and an occasional specimen may be picked out very closely resembling certain varieties of that species. It differs, however, in having the umbo of its ventral valve more prominent, thus giving a more ovate form to the entire outline than we see in *R. radialis*. Our shell is also much less variable in the number of its costæ, of which there are nearly always fourteen to each valve. I have never seen a specimen with more than sixteen or seventeen, while *R. radialis*, although sometimes not having more than fourteen or fifteen, *generally* has about twenty. A more important difference, however, is to be observed in the nature of the obscure mesial sinus sometimes observed in the ventral valve of our shell, which is not produced by a wider and deeper sulcus between two of the costæ, but by the depression of one or two of the costæ themselves; nor does this faint sinus produce any traces of a corresponding ridge in the other valve, as in *R. radialis*.

Professor Geinitz cites my *R. compressa*, from the Carboniferous rocks of California, as a synonym of the form under consideration. In this, however, he is certainly in error, that species being a much more compressed shell, with only about half the number of costæ, which are also proportionately more prominent. To me, the *R. punctulifera* seems more nearly allied to *R. radialis*, Phillips, than *R. compressa* is to *R. punctulifera;* so that if we were to include the California shell as a variety of *R. punctulifera*, both of the latter might, with at least as much propriety, be arranged as synonyms of Phillips's species.

I am in doubt whether Dr. Shumard's name, *R. punctulifera*, or Professor Marcou's name, *Terebratula Mormonii*, for this shell, has priority, both having been published in 1858. If Professor Marcou's name was published earlier in the year than Dr. Shumard's, it would of course have to be retained. If the two names, however, were published at exactly the same date, or so near it as to leave the question of priority in doubt, the name *punctulifera* should be retained, as it was proposed along with a much better description, and with a correct knowledge of the affinities of the shell.

Locality and position.—The specimen figured on Pl. I was, with many others, found at Rock Bluff, on the Missouri, referred by Professor Marcou to the Lower Dyas, and by Professor Geinitz to the Coal-Measures, to which latter horizon this outcrop certainly belongs. We also find it at Plattsmouth; in the division B, at Nebraska City; at the same horizon at numerous other localities, as well as at various positions in the Coal-

*See Report Regents University, N. Y., on State Cab. N. H., 1864, p. 64.

Measures of Nebraska, Kansas, Illinois, and the adjoining States; in short, it is a widely-distributed Coal-Measure species.

Genus SPIRIFER, Sowerby.

SPIRIFER CAMERATUS, Morton.

Pl. VI, Fig. 12; and Pl. VIII, Fig. 15.

Spirifer cameratus, Morton, 1836, Am. Jour. Sci., Vol. XXIX, p. 150, Pl. II, Fig. 3; Hall, 1856, Pacific Railroad Report, Vol. III, p. 102, Pl. II, Figs. 9, 12, and 13; and 1858, Iowa Geol. Report, 1, Part II, p. 709, Pl. XXVII, Fig. 2 *a*, *b*.
——*meusebachanus*, Roemer, 1852, Kreid. Von Texas, p. 88, Pl. XI, Fig. 7.
——*triplicatus*, Hall, 1852, Stansbury's Report Salt Lake Exp., p. 410, Pl. II, Fig. 5, (by error Pl. 4.)
——*fasciger?* (v. Keyserling), Owen, 1852, Report Wisconsin, Iowa, and Minn., Pl. 5, Fig. 4.
Spirifer ——— H. D. Rogers, 1858, Geological Report Pennsylvania, Vol. II, p. 833, Fig. 694.
Compare *S. fasciger*, v. Keyserling, 1847, Petschora-land, p. 231, Pl. 3, Fig. 3.

Shell attaining a medium size, transversely semicircular or subtrigonal, more or less gibbous; cardinal margin nearly always equaling the greatest breadth of the shell, sometimes extended into pointed ears. Dorsal valve rather less convex than the other; beak but little prominent, and scarcely extending beyond the hinge—together with the narrow area, rather distinctly incurved; mesial fold prominent, subangular or narrowly rounded, commencing narrow at the beak and widening and deepening rapidly to the front. Ventral valve with beak rather prominent and incurved; area distinctly defined, of moderate height, with subparallel margins, and extending nearly or quite to the lateral extremities of the hinge, more or less straightened and arched; foramen forming a nearly equilateral triangle; mesial sinus corresponding to the fold of the other valve, extending to the beak. Surface ornamented with distinct, irregular, or unequal, more or less bifurcating, radiating costæ, both on the mesial fold and within the sinus, as well as on each side of the same, those on the sides showing a more or less marked tendency to group themselves into fasciculi, which are each composed, at the front, of from three to seven or eight ribs, only the middle one of which usually extends quite to the beaks; marks of growth moderately distinct near the free margins, but never forming raised lamellæ.

Length of a well-developed adult specimen, 1.35 inches; breadth, 2 inches; convexity, 1 inch.

This is one of our most common and widely distributed Coal-Measure fossils, and, like other species of the genus, it varies considerably both in form and some of its other characters. Some individuals are quite gibbous with a comparatively short hinge, and rather obtuse lateral extremities; while others are less convex, have the hinge line considerably extended, and the lateral extremities acutely angular. The fasciculated character of the costæ is also, to some extent, a variable character, though it is generally more or less marked, and often very strongly defined. Some of the extreme varieties look quite distinct enough to be considered different species, if it were not for the numerous intermediate gradations. One of these extremes, with an extended hinge line terminating in pointed extremities, and provided with rather fine, imperfectly fasciculated costæ, Professor Swallow has proposed to call *S. cameratus*, var. *Kansasensis*.

It is a remarkable fact, that this latter variety is almost exactly like certain varieties of the well-known *S. striatus*. Indeed, some of the best authorities of Europe have regarded even the typical S. cameratus as

merely a variety of *S. striatus*. Yet in this country, although we have a form (*S. Logani*, Hall) agreeing well with the large typical *S. striatus*, the *S. cameratus* is in all its varieties strictly a Coal-Measure shell, and can be distinguished at a glance from all of our Lower Carboniferous species.

Professor Geinitz cites Mr. Davidson's *S. Moosakhailensis*, from Punjaub, India, as a synonym of *S. cameratus*, but in this he is certainly in error, as that species is characterized by distinct, regularly disposed, raised lamellæ of growth, over the entire surface; a character never seen on the American shell. It is far more probable, however, as supposed by Dr. Owen, that *S. fasciger* of Keyserling is a synonym of this shell.

Locality and position.—This species ranges through the whole Coal-Measures of this country, and up into the series called Permo-carboniferous by Dr. Hayden and myself in Kansas. It is more abundant, however, in the Upper than the Lower Coal-Measures. It occurs in division C of the Nebraska City section, and has been found by Dr. White in Iowa, and by Dr. Hayden and myself in Kansas, in beds believed to hold the same position. It is common in division B at Nebraska City and vicinity, and at various lower positions in the Coal-Measures of that and the adjoining States. It also occurs in the Coal-Measures of Eastern Ohio, West Virginia, and Pennsylvania, and ranges south into Texas and New Mexico.

SPIRIFER [MARTINIA] PLANOCONVEXUS, Shumard.

Pl. IV, Fig. 4, *a*, *b*; Pl. VIII, Fig. 2, *a*, *b*.

Spirifer planoconvexus, Shumard, 1855, Report Missouri Geological Survey, p. 202; Meek and Hayden, 1864, Palæont. Upp. Missouri, Part 1, pp. 20 and 21, Figs. *a*, *b*, *c*, *d*, *e*; Geinitz, 1866, Carb. und Dyas in Neb., p. 42, Tab. III, Figs. 10, 11, 12, 13, 14, 15, 16, 17, 18.

Ambocœlia gemmula, McChesney, 1860, Descr. Pal. Foss., p. 41; also 1865, Fig. 3 *a*, *b*, *c*, Pl. I, illustrations of same.

Martinia planoconvexa, McChesney, 1869, Trans. Chicago Acad. Sci., Vol. I, p. 34, Pl. I, Fig. 3.

Compare *Spirifer Urii*, Fleming, 1828, British Animals, p. 376.

Shell very small, plano-convex, or very rarely even a little concavo-convex, sometimes wider than long, in other examples slightly longer than wide; hinge margin always shorter than the greatest transverse diameter of the valves, and rounded at the extremities; lateral margins and front regularly rounded; surface apparently smooth, excepting a few very obscure concentric marks of growth, but when examined by the aid of a magnifier, showing remains of the bases of minute hair-like spines. Dorsal or smaller valve truncato-suborbicular in outline, generally nearly flat, with a faint longitudinal depression in front, sometimes slightly convex near the beak, and concave around the anterior and lateral margins; beak scarcely distinct from the cardinal margin; area narrow, but well developed, or about half as large as in the other valve; socket plates a little projecting, like diverging teeth on each side of the small fissure. Ventral valve very gibbous, particularly in the umbonal region, sometimes with obscure traces of a narrow longitudinal depression along the middle, but without a proper mesial sinus; beak very prominent, and strongly arched back over the hinge; area subtriangular, being moderately high under the beak, but narrowing rapidly, with moderately defined concave margins, to the extremities of the hinge, and arching with the beak; fissure rather narrow, or higher than wide, apparently rounded above under the beak, and spreading at the *hinge*.

Length of a medium-sized specimen, 0.30 inch; breadth, 0.31 inch; convexity, 0.17 inch.

This abundant little shell agrees so closely with *Spirifer Urii* of Fleming, that I have been somewhat inclined, as elsewhere stated, to think it may really be a variety of that species. The only differences I have been able to see, consist in its more flattened, or, in some instances, partly concave dorsal valve, and the general (though not constant) absence of any traces of a mesial sinus in its ventral valve. The fissure of its ventral valve seems also to be narrower, and, so far as known, not partly closed by a false deltidium.

Locality and position.—Very abundant in division C of the Nebraska City section; also common in division B at that place; at Bennett's Mill, Wyoming, and at apparently a higher horizon at Morton's and Werth's places, one and three-fourths to two and three-fourths miles west of Nebraska City. It is likewise common in still lower positions at Cedar Bluff, on Weeping Water; Rock Bluff, Plattsmouth, &c., on the Missouri; and less abundantly at Bellevue and Omaha. We also found it at Brownville, Otoe City, Rulo, &c.; indeed, it is one of the most common fossils of our western Coal-Measures in Iowa, Missouri, Nebraska, Kansas, &c.; and I have seen it among some collections sent by Dr. Stevens from the Coal-Measures near Pittsburg, Pennsylvania. I have likewise identified it among specimens sent by Professor J. J. Stevenson from the Lower Coal-Measures of West Virginia.

Genus SPIRIFERINA, d' Orbigny.

SPIRIFERINA KENTUCKENSIS, Shumard.

Pl. VI, Fig. 3 *a*, *b*, *c*, *d*; and Pl. VIII, Fig. 11 *a*, *b*.

Spirifer octoplicatus, Hall, 1852, Stansbury's Salt Lake Report, p. 409, Pl. XI, Fig. 4, *a*, *b*; (not Sowerby ?, 1827).
—— *Kentuckensis*, Shumard, 1855, Missouri Geological Report, p. 203; Hall, 1856, Pacific Railroad Report, Vol. III, p. 103, Pl. II, Fig 10–11.
—— *laminosus*, Geinitz, 1866, Carb. und Dyas in Neb., p. 45, Tab. III, Fig. 19 *a*, *b*, *c*, *d*; (not *S. laminosus*, McCoy).

Shell rather small, varying from subglobose, to semicircular, or even subfusiform, always wider than long; breadth sometimes twice or even three times the length; hinge line always equaling the greatest breadth of the valves, occasionally greatly extended, and terminating in slender mucronate ears; anterior and lateral margins generally forming a nearly semi-circular curve.

Ventral valve somewhat more convex than the other, the greatest convexity being between the beak and the middle; beak moderately prominent, and rather distinctly arched or incurved; area arched, usually of moderate height, well defined, and extending nearly or quite to the lateral extremities, highest in gibbous specimens, in which it is narrow near the extremities, while it increases rapidly in height, with concave lateral margins, toward the beak; foramen, generally higher than wide, with a marginal furrow on each side, and, so far as known, not closed by a deltidium; mesial sinus narrow, rather deep, sometimes with a small obscure rib along its middle, but more frequently without it; plications on each side of the sinus from about five to eight or nine, rather narrow, simple, prominent, and a little rounded; mesial septum of interior moderately prominent.

Dorsal valve with greatest convexity near the middle; beak scarcely

projecting beyond the hinge margin, more or less incurved; area very narrow, and incurved with the beak; mesial fold narrow, not very prominent, nor greatly larger than the first plication on each side, most generally rounded, but not infrequently with an obscure sulcus along the middle, near the front; lateral plications as in the other valve.

Entire surface of both valves ornamented with numerous closely crowded, very regularly arranged, subimbricating lamellæ of growth, strongly arched in passing over the costæ; over the whole may also be seen, by the aid of a magnifier, numerous granules, apparently connected with the punctures passing through the shell, which are comparatively large and distant, though regularly arranged.

Breadth of a well developed, rather gibbous specimen, with the hinge line not greatly extended, 0.55 inch; length, 0.38 inch; convexity, 0.33 inch.

This species varies extremely in form, some specimens being almost subglobose, with the hinge line not extended beyond the general breadth of the valves near the middle; while other individuals have the lateral extremities greatly extended and pointed, even in some cases more so than in the specimen represented by our figure. For these most extended forms, Professor Swallow has proposed in the St. Louis Academy's Transactions the name *Spirifer propatulus*, as a variety of the *S. Kentuckensis*. After a careful comparison and study of an extensive series of specimens, it seems to me that there are all degrees of intermediate gradations between these extremes of form.

Some of the less drawn out, or more nearly globose varieties, appear to me to be so nearly like *Spiriferina octoplicata*, Sowerby, that it would certainly be very difficult to point out any reliable characters (yet known) by which they can be separated. The fact, however, that these are so inseparably connected with the others, greatly extended transversely, and in this respect so very different from *S. octoplicata*, as figured and described in European works, is at least a sufficient reason for doubting the specific identity of the American and European forms.

Mr. Davidson, however, wrote to me that gibbous specimens sent to him from Nebraska, would scarcely be thought distinct from *S. octoplicata* if found in British Carboniferous rocks.

The only specimens I have seen from division C of the Nebraska City section being too imperfect to figure, I have reproduced Professor Geinitz's figures of specimens from that division. We found nearly all the varieties of this shell, however, at that locality in the next division below, and the figures 3 *a* and 3 *d*, Pl. VI, are given to illustrate the extremes of form. Fig. 3 *c*, same plate, shows the interior of a ventral valve from the latter locality and position with its mesial septum.

Prof. Geinitz was certainly in error in referring this shell to *S. laminosus*, McCoy, which is a much larger species, with so high an area that Professor McCoy even thought it a *Cyrtia*.

Locality and position.—This species is found in divisions C and B, at Nebraska City; and at numerous localities and various position in the upper Coal-Measures of Kentucky, Illinois, Missouri, Iowa, Nebraska, Kansas, &c., south to Texas and New Mexico; also in the Lower Coal-Measures of Illinois and Iowa.

Genus TEREBRATULA, Llhwyd.

TEREBRATULA BOVIDENS, Morton.

Pl. I, Fig. 7 *a*, *b*, *c*, *d*, and Pl. II, Fig. 4.

Terebratula bovidens, Morton, 1836, Am. Jour. Sci., Vol. XXIX, p. 150.
—— *bovidens ?*, Hall, 1858, Iowa Geol. Report, Vol. I, Part II, p. 711; McChesney, 1869, Trans. Chicago Acad. Sci., Vol. I, p. 37, Pl. I, Fig. 2.
—— *millepunctata*, Hall, 1856, Pacific Railroad Report, Vol. III, p. 101, Pl. II, Fig. 1 and 2.
—— *geniculosa*, McChesney, 1861, Descriptions New, Palæozoic Foss., p. 82; also 1865, illustrations same, Pl. I, Fig. 2 *a*, *b*, *c*.
Compare *Terebratula arcuata*, Swallow, 1862, Trans. St. Louis Acad. Sci., II, p. 83.

Shell ovate, rounded and rather compressed at the anterior and anterior lateral margins, and most convex a little behind the middle; valves nearly equally convex; ventral valve strongly arcuate longitudinally, and presenting a regularly increasing curve, from the front to the beak, which is moderately prominent, and very strongly and closely curved over and upon that of the other valve; foramen a little oval, and not truncating the immediate apex of the beak, but situated directly outside of it; mesial sinus rather wide, and rounded at the front, but narrowing and becoming less deep further back, until it dies out near the curve of the umbo, which is sometimes slightly flattened. Dorsal valve often nearly straight, or but slightly convex, along the middle, from the beak to the front, where its margin is usually somewhat raised for the reception of the slightly produced margin of the other valve at the termination of the sinus; sides sloping from the middle to the lateral margins along nearly the entire length of the valve; beak terminating directly under that of the other valve, without any distinct curvature. Surface nearly smooth, or only showing moderately distinct marks of growth; and, by the aid of a magnifier, exhibiting very distinctly the moderately large regularly arranged punctures.

Length of a medium-sized individual, 0.64 inch; breadth of ditto, 0.50 inch; convexity, about 0.28 inch.

This shell often exhibits almost *exactly* the external form and appearance of *T. elongata*, Schlot., as figured by Professor Geinitz, in his work on the German Permian fossils (Dyas), Pl. XV, particularly the form represented by his figures 14 and 15. This resemblance is so striking that there can be no doubt whatever that he would have unhesitatingly referred the Nebraska shell to that species, had Professor Marcou found it.

Mr. Davidson and several other good authorities on the *Brachiopoda* regard the Permian *T. elongata* and *T. sufflata* as only varieties, or recurrent forms of the Carboniferous *T. hastata*. However this may be, I can only say that our shell is *very constant* in its characters, never presenting but slight variations from the forms figured on Pl. I, which will be seen to resemble most nearly the *T. elongata* of the European Permian rocks, as figured by Professors King and Geinitz. Were it not for the fact that the foramen of that shell truncates (according to Professor King) the immediate extremity of the beak, instead of perforating it a little outside of its apex, I confess it would be extremely difficult, if not impossible, to separate our shell, upon any known external characters from certain forms of *T. elongata*. Yet I am assured by Dr. White that he has ground off Iowa specimens, in no way distinguishable from *T. bovidens*, so as to show the loop through the translucent calcareous matter filling the interior, and that it is elongated as in *Waldheimia*, and not short as in true *Terebratula*. If the appearance of a long loop, *seen by Dr. White, is not* due to some other cause, of course

our shell cannot be properly referred to any variety of *T. elongata*, or other allied European form of true *Terebratula*.

Professor Swallow has described, under the name *T. arcuata*, from the Lower Carboniferous rocks at Chester, Illinois, a shell agreeing apparently exactly, in all external characters, with this, but it is desirable that their internal characters should be compared before arriving at any positive conclusions respecting their identity.

Locality and position.—The specimen represented on Pl. II, Fig. 4, was found at Plattsmouth, and figures 1 *a*, *b*, *c*, on Plate I, are from a specimen found three miles up Platte River, on the north side, in a bed holding a position a little lower than those at Plattsmouth. Fig. 7 *d*, represents a larger specimen from the Coal-Measures of Indian Creek, Kansas. Professor McChesney figured it from the Upper Coal-Measures of La Salle, Illinois; and Professor Hall from the same horizon in New Mexico. Dr. Morton first figured and described it from the Coal-Measures of Ohio. It also occurs at various localities in the Upper Coal-Measures of Iowa, Missouri, and Kansas, as well as in the Lower Coal-Measures of Illinois, though it is not usually abundant at any one locality.

LAMELLIBRANCHIATA.

Genus LIMA, Bruguiere.

LIMA RETIFERA, Shumard.

Pl. IX, Fig. 5.

Lima retifera, Shumard, 1858, Trans. St. Louis Acad. Sci., 1, p. 214; Geinitz ?, 1866, Carb. und Dyas in Neb., p. 36, Tab. II, Figs. 20 and 21.

Shell obliquely subovate, moderately convex, apparently not gaping in front; hinge line short, or between one-half and one-third the antero-posterior diameter of the valves; base forming a nearly regular semicircular curve; anterior side extended obliquely forward, rather narrowly rounded below, and straight or slightly concave in outline, with a rather long oblique slope to the hinge above; posterior side distinctly shorter than the other, and rounding from near the ear into the base; ears subequal, the front margin of the anterior one forming an obtuse angle with the hinge line, rather distinctly flattened from the swell of the umbo, and somewhat extended along the anterior margin below; posterior ear a little more convex than the other, with its upper margin incurved, and its lower margin separated from the umbo by a faint oblique furrow, sometimes faintly sinuous behind, and nearly rectangular at its extremity; umbones rather convex or moderately compressed, extending very little above the cardinal margin, and placed near the middle of the same; surface ornamented by about twenty-five slightly irregular, angular, radiating costæ, about equaling the spaces between, and occasionally bifurcating on the umbones and lateral margins of the body part of the valves, where they become obsolete; crossing all of these, as well as on the ears and lateral margins, are numerous fine concentric striæ.

Height of a well-developed specimen, 0.50 inch; antero-posterior diameter of same, 0.62 inch; convexity, about 0.40 inch; length of hinge, 0.27 inch.

A fine series of specimens of this shell now before me shows it to agree well with Dr. Shumard's description, and I have no doubt in regard to its identity with his species. It should be borne in mind, however, in

aking comparisons with his description, that he has inadvertently de-ribed the longer or anterior side as the anal side, and the posterior as ıe buccal side. I fully agree with Dr. Shumard in regarding it as hav-ıg, at least, all the external characters of a true *Lima*. I am aware this ıct may be appealed to as an evidence that these beds should be in-ıded in the Permian; but it should not be forgotten in this connection ıat the species was originally described by Dr. Shumard from ac-nowledged Coal-Measure beds in the valley of Verdigris River, Kansas, here it was found directly associated with the well-known Carbonifer-us types *Fusulina cylindrica* and *Productus Nebrascensis*. The only re-ıaining portion of the shell of this species, in all the specimens I have een, is a thin layer preserving the surface markings so distinctly as to eave the impression that it is the outer layer; yet, in examining it by he aid of a high magnifier and a strong transmitted light, it seems to ıresent a prismatic structure.

Locality and position.—Division C of the Nebraska City section, and in he Coal-Measures on Verdigris River, Kansas. It also ranges through he whole of the Coal-Measures of Illinois.

Genus ENTOLIUM, Meek.

ENTOLIUM AVICULATUM, Swallow, sp.

Pl. IX, Fig. 11 *a*, *b*, *c*, *d*, *e*, *f*.

Pecten aviculatus, Swallow, 1858, Trans. St. Louis Acad. Sci., Vol. I, p. 215.

Shell compressed lenticular, very thin, nearly or quite equivalve, sub-orbicular, or broad subovate in outline exclusive of the ears, the antero-posterior diameter being often a little less than that at right angles to the same; sides and base more or less regularly rounded; lateral mar-gins above the middle apparently a little gaping, straight, and converging to the beaks at an angle of 115° to 125°; cardinal margin very short, or less than one-third the transverse diameter of the valves, and in the left valve generally concave, or more or less sloping in outline, from the extremities of the ears to the beaks; straight or nearly so in the right valve; ears small, flat, very nearly equal, obtusely angular at the ex-tremities, and separated from the body of the valves by an impressed line, not defined by any proper sinus in either valve, though the broad obtuse notch separating the anterior one from the straight, sloping ad-jacent margin is slightly more defined than the other; beaks small, rather compressed, equal, and not projecting beyond the cardinal margin. Each valve with two shallow undefined impressions diverging from the beak nearly to the anterior and posterior margins; that on the posterior side being longer than the other.* Surface with very fine close concen-tric striæ scarcely visible without the aid of a magnifier; crossing these re also sometimes seen traces of extremely minute radiating striæ, curv-ıg gracefully outward toward the lateral margins.†

Antero-posterior diameter of a specimen a little under medium size, 85 inch; height, 0.89 inch; length of hinge line, 0.27 inch. Specimens re sometimes found of nearly double these dimensions.

* Owing to the thinness of the shell these impressions appear as ridges on the inside of e valves.

† In most of the specimens these radiating striæ are entirely obsolete, even as seen ıder a magnifier; and it is generally only on specimens that have been slightly weath-ed that they are most distinctly seen, while even on these they seem to be more due some peculiarity of the shell *structure*, than proper *surface* sculpturing, the shell owing a disposition to crack along these curved lines. Both these and the concentric riæ are almost invisible *to the unassisted eye*.

This shell evidently belongs to a group for which I proposed, in the California Report, the name *Entolium*, with *Pecten demissus*, Phillips (not Fleming), as illustrated in Quenstedt's Der Jura, Pl. 48, Fig. 6, as the type. At the time of proposing this name I was under the impression that the valves of these shells were closed on each side, but the species here under consideration seems to have been gaping on the sides above the middle. This being the case, I am not sure the group is more than subgenerically distinct from *Pseud-amussium*, Brug., 1789.* It differs from *Amussium* mainly in having no internal costæ, and in having the valves more nearly equal, with, sometimes, minute radiating striæ, and no traces of a sinus under the anterior ear in either valve. The species known to me have the cardinal margin of the left valve angulated in outline by the elevation of the extremity of the ears; while that of the right valve seems to be straight, and articulatd in a little transverse groove of the other valve, not always defined, however (see Fig. 14 *g, g*, Pl. IX, copied from Quenstedt's figure of *Pecten demissus*, taken from an impression of the hinge left in the matrix). The cartilage pit is as in other allied types of the *Pectinidæ*, while diverging from it are two elongated tooth-like ridges (*t, t* of Quenstedt's figure). These, however, do not seem to have been properly teeth, fitting into sockets, but appear to have been a little raised in both valves, and occupy a position between the ears and the broad diverging impressions, descending obliquely from the beaks.

On some of the internal casts of this shell I have noticed some very singular fine sculpturing, rather difficult to account for. It closely resembles the zigzag markings seen on the surface of the group of *Nucula* for which H. and A. Adams proposed the name *Acila;* but is exceedingly fine and obscure, being formed by numerous very regularly and closely arranged, distinctly zigzag lines, traversing the valves with a general direction parallel to the curve of the marks of growth. Fig. 11 *d*, of Plate IX, shows these markings as seen by the aid of a magnifier. The most singular fact in regard to these zigzag lines is that they have no connection whatever with the surface striæ, since they are only seen on internal casts, often retaining portions of the shell, with the usual minute concentric lines, and showing no trace externally of these inner markings. They seem also to be more frequently seen on casts of the left valve, though on casts of many of the left, and apparently all of those of the right, they are entirely wanting. In regard to their complete absence from the interior of right valves, there may be some room for doubts, as it is only under the most favorable circumstances, where casts have been formed of exceedingly fine clays, that they are to be seen. They are possibly, as it were, a sort of effort at internal markings, of a very different kind, but in some respects analogous to the internal costæ of *Amussium*.

Professor Winchell, in 1865, proposed the name *Pernopecten* for a type (*Aviculopecten limaformis*, White and Whitfield) from near the base of the Lower Carboniferous, that agrees exactly with this, in all external characters, but differs in having, in addition to the central cartilage pit, a row of minute pits or crenulations along the whole hinge line. From *Camptonectes* of Agassiz, the shell under consideration differs in having

* Klein first used the name *Pseudo-Amusium*, in 1753, and H. and A. Adams have proposed to adopt it for a group including some forms more or less like our shell, and others quite distinct. If the name is to be retained, however, Bruguiere should, I would think, have to be regarded as the author of the genus, as Klein was not a binomial author, while Bruguiere is the first binomial author that used it after the introduction of the binomial nomenclature, and with a diagnosis. He limited it to smooth species with only fine radiating striæ.

no sinus under the anterior ear of either valve, and in wanting the distinct radiating curved surface striæ.

It is certainly congeneric with *Pernopecten Shumardi* of Winchell (which seems to be the same shell previously described by Dr. Shumard in the Missouri report under the name *Avicula Cooperensis**), and I must confess that I cannot clearly see how it differs even specifically, although the two shells came from widely different horizons. The species *Cooperensis*, or *Shumardi*, came from the lowest division of the Carboniferous in Missouri and Iowa, and occurs in the same horizon in Ohio. I have seen its hinge, however, and it has not the crenated character of the type of *Pernopecten*, but agrees with that of the shell under consideration, as the species does in all other known characters.

Compared with European species, our shell will be seen to be very nearly allied to *Pecten Sowerbyi* of McCoy (Carb. Fossils of Ireland, p. 100, Pl. XIV, Fig. 1), from the Carboniferous rocks of Ireland, which can scarcely belong to any other group than this, though it would appear to differ specifically, in having stronger concentric markings, without any traces of the minute obscure radiating striæ sometimes seen on this, as well as in having its ears more pointed and elevated, as may be seen by Fig. 13 *a* of our Plate IX, reproduced from McCoy's original figure. It is worthy of note that McCoy has noticed (British Palæozoic Fossils, p. 475) that exfoliated laminæ of his species exhibit minute zigzag divaricating, scratch-like markings, like those observed in that here under consideration.

Locality and position.—This species is common in division C of the Nebraska City section. It also occurs in division B, at Bennett's Mill, three miles northwest of Nebraska City, and at lower positions in the Coal-Measures at Plattsmouth, and at several localities near Rock Bluff on the Missouri. Dr. White has found it at various localities in the Upper Coal-Measures of Iowa, and it occurs in the same horizon in Kansas, from which position it was first described, by Professor Swallow. It likewise occurs in both the Upper and Lower Coal-Measures of Illinois.

Genus AVICULOPECTEN, McCoy.

AVICULOPECTEN OCCIDENTALIS, Shumard, sp.

Pl. IX, Fig. 10.

Pecten occidentalis, Shumard, 1855, Missouri Report, p. 207, Pl. C, Fig. 18; (not Winchell).
——— *Clearelandicus*, Swallow, 1858, Trans. St. Louis Acad. Sci., Vol. I, p. 184.
Aviculopecten ———?, Meek and Hayden, 1864, Paleont Upper Mo., p. 50, Pl. II, Fig. 10.
——— *occidentalis*?, Meek and Worthen, 1866, Geol. Report, Illinois, Vol. II, p. 331, Pl. XXVII, Fig. 4 and 5.
Pecten Missouriensis?, Geinitz, 1866, Carb. und Dyas in Neb., p. 35, Tab. II, Fig. 18; (not Shumard, 1855).

Shell distinctly inequivalve, not oblique; subovate exclusive of the ears; lateral and basal margins regularly rounded; hinge margin nearly or quite equaling the greatest breadth of the valves; cardinal plate of moderate breadth. Left valve convex, with ears subequal; anterior one with distinct radiating costæ, more convex, shorter, and more obtuse than the posterior, as well as more defined from the swell of the umbonal

* It should be mentioned here that the engraver exaggerated the very obscure ribs sometimes (but rarely) seen on Shumard's species, in the figure given in the Missouri report, and that the out line of the right ear of the same figure is not exactly correct. The species is nearly always destitute of any traces of ribs, as I know from examining numerous specimens from the original locality. These agree exactly with Prof. Winchell's *P. Shumardi*.

slope; posterior ear flattened and more angular at the extremity than the other, sometimes without radiating costæ, but in other instances having them more or less developed, each separated from the margin below by a rounded, rather broad, more or less deep, sinus. Right valve nearly flat, and having the general outline of the other, excepting that its beak is scarcely distinct from the cardinal margin, and its anterior ear much narrower, and defined by a deep, sharply angular sinus. Surface of left valve ornamented with rather depressed or flattened irregular radiating costæ, of which only about twelve or fourteen of the largest reach the beak, the others dying out at various distances between the margins and the umbo, in proportion to size, the larger of the intercalated ones being longer than the smaller; crossing all of these are numerous fine concentric striæ, some of which on the ears, particularly on the anterior one, often form little vaulted scales; in well-preserved specimens these vaulted projections are strongly developed on one of the posterior costæ of the body part of the valve. Surface of right valve with generally only very obscure radiating costæ, and fine crowded lines of growth.

Height of a rather large specimen, 1.65 inches; breadth, from 1.40 to 1.55 inches; convexity, about 0.28 inch.

The foregoing description is taken from well-preserved specimens, showing the surface markings better than any examples I had previously seen. As usually found in the condition of casts, the vaulted scales mentioned on the wings, and a few of the lateral costæ, are entirely absent. This character is also variable in specimens showing the surface well preserved, it being scarcely possible to find any two individuals with it equally well developed, while in many instances it is nearly or entirely wanting.

I have copied Professor Geinitz's figure, because we found no example of this shell in Professor Marcou's bed C, at Nebraska City. If this figure is accurately drawn, the specimen from which it was made may possibly be a different species, since it represents the anterior ear of the left valve more angular than I have ever seen it in this shell. This, however, is probably a slight error in the drawing in restoring a portion of the ear partly broken away or hidden in the matrix, since among the great numbers of specimens I have seen from these rocks, at numerous localities in that and the adjoining States, there is no otherwise similar shell agreeing with this figure in this respect. His specimen being a cast, of course does not show the vaulted scale-like surface character mentioned in the foregoing description. Professor Geinitz was certainly mistaken, however, in referring the form he has figured to *A. Missouriensis* of Shumard, which is a smaller species, unknown above the St. Louis Limestone of the Lower Carboniferous series.

Locality and position.—Aviculopecten occidentalis has an extensive geographical distribution, as well as a considerable vertical range. It occurs at numerous localities in the Upper Coal-Measures of Illinois, Missouri, Iowa, Eastern Nebraska, Kansas, and Kentucky, as well as in the Lower Coal-Measures of the first mentioned State; and has been found near the Black Hills. It occurs in the Coal-Measure rocks above the Platte, in Iowa and Nebraska, referred by Mr. Marcou to the Mountain Limestone; in those at the mouth of Platte River referred by him to the Lower Dyas; and at Rock Bluff, Bennett's Mill, Wyoming, Nebraska City, &c., in beds included by him and Professor Geinitz to the Upper Dyas. In Kansas it ranges through the whole Upper Coal-Measures, and Permo-carboniferous, into the Permian. I have never seen it at any western locality in any of the Lower Carboniferous or older

rocks; but from Nova Scotia I have seen casts of a form that could not be distinguished from it, obtained from beds generally regarded as Lower Carboniferous.

AVICULOPECTEN NEGLECTUS, Geinitz, sp.

Pl. IX., Fig. 1 *a*, *b*.

Pecten neglectus, Geinitz, 1866, Carb. und Dyas in Neb., p. 33, Tab. II, Fig. 17.
Aviculopecten neglectus, Meek, 1867, Am. Jour. Sci. & Arts, Vol. XLIV, sec. ser., p. 183.

Shell very small, broad subovate exclusive of the ears, very thin, rather compressed; sides and base more or less regularly rounded; cardinal margin shorter than the breadth of the valves. Left valve (according to Professor Geinitz's figure) with ears nearly equal, the anterior one separated from the margin below by a broad, very shallow sinus, and forming less than a right angle at its extremity; posterior ear extending farther down the margin than the other, very faintly sinuous behind, and forming an angle of about 100° at the extremity. Right valve with anterior ear narrow and rather acutely angular, defined by a deep, narrow sinus, extending back about half its length; posterior ear of about the same length, but of greater vertical breadth than the other, rather pointed at the extremity, and defined by a moderately deep, broadly rounded sinus, and a subangular umbonal slope. Surface of the body part of both valves apparently only marked by fine concentric striæ; ears with a few radiating costæ, crossed by fine striæ and a few coarser marks of growth.

Height and breadth each, 0.26 inch; length of hinge, 0.21 inch.

This little species is rather remarkable in having the body part of the valves with apparently only fine concentric striæ, while the ears are ornamented with a few comparatively distinct radiating costæ. I know of no species with which it is liable to be confounded.

The specimen figured by Professor Geinitz is a left valve, while those I have seen are all right valves. The latter are mainly casts, but one of them retains portions of the shell. On raising a small piece of this with the point of a knife, and placing it under the microscope, where it could be examined by a strong transmitted light, it was found to present distinct indications of a prismatic structure, apparently not due to crystallization. As this, the only remaining portion of the shell, is exceedingly thin, and consists of a single apparently prismatic layer, I have little doubt that the inner laminated portion of the shell has been dissolved away, as seems to have been the case in other species in these rocks.

Locality and position.—Division C of the section at Nebraska City. It also occurs both in the Upper and Lower Coal-Measures of Illinois.

AVICULOPECTEN CARBONIFERUS, Stevens, sp.

Pl. IV., Fig. 8, and Pl. IX, 4 *a*, *b*.

Pecten carboniferus, Stevens, 1858, Am. Jour. Sci. and Arts, Vol. XXV, p. 261.
—— *Broadheadii*, Swallow, 1862, Transactions St. Louis Academy Sci., Vol. II, p. 97.
—— *Hawni*, Geinitz, 1866, Carb. und Dyas in Neb., p. 36, Tab. II, Fig. 19 *a*, *b*.

Shell rather small, slightly oblique, moderately convex, length and breadth nearly equal; hinge line nearly or quite straight, and somewhat less than the greatest breadth of the valves, provided with a marginal ridge in both valves; basal margin regularly rounded. Left valve more convex than the other; posterior ear rather well defined from the swell

of the umbo, somewhat extended and terminating in an acute point, separated from the margin below by a deep rounded sinus; anterior ear about two-thirds as long as the other, and rather more distinct from the umbo and more obtuse, but still rather acutely angular, defined by a moderately distinct subangular sinus. Right valve nearly flat, or distinctly less convex than the other; its anterior ear narrow, and defined by a deep, rather sharp sinus; posterior ear of the same size and form as in the left valve. Surface ornamented in the left valve with about fifteen or sixteen regular, distinct, angular, radiating plications, separated by furrows of the same size, each one of which terminates at the free border in a little spine-like projection with curved-up margins; lines of growth fine on the body of the valve, but becoming more distinct and irregular on the ears, where there are rarely any defined radiating costæ. At a few distantly separated intervals there are prominent imbricating laminæ of growth, showing the same digitate margins as the free borders of the shell. In the right valve the surface markings are somewhat like those of the other valve, but much more obscure, excepting on the anterior wing, where there are a few more distinct radiating costæ.

Height of the largest specimen seen, 0.73 inch to extremity of projecting marginal spines; breadth, 0.75 inch; length of hinge, 0.57 inch.

In all of sixteen or eighteen individual specimens I have seen, of the left valve, the sinuous posterior margin under the wing is smoothly rounded in outline. In one individual, however, agreeing in all other respects with the others, this part of the margin is evidently also provided with a few smaller projecting points than those at the terminations of the furrows between the costæ on the body of the valve. There were no radiating furrows or costæ, however, on the ear corresponding to those little projections.

The flattened right valves of this species I have seen, are not in a condition to show very clearly whether its free margin is digitate, like that of the other, though it seems not to be: at any rate not so distinctly so.

On first seeing Professor Geinitz's figure of this shell, I believed it to be the same species described from the Upper Coal-Measures of Northwestern Missouri by Professor Swallow, under the name *Pecten Broadheadii*. Some time after, I wrote to Mr. Broadhead, who discovered the typical specimens described by Professor Swallow, and requested him to send me a specimen of the *P. Broadheadii* from the original locality, which he kindly did, and it proved to be exactly the same shell figured by Professor Geinitz. Still later, I notice among the descriptions of some fossils from the Coal-Measures of Illinois, published by Dr. Stevens in 1858, one of a *Pecten* that seemed to agree quite well with the *P. Broadheadii*, and on examining a good series of specimens from the same locality, I found the same shell quite common among them; and Dr. Stevens has also assured me that Professor Geinitz's figure, of which I sent him a tracing, certainly represents his species.

The only specimens of this species I have seen consist entirely of what seems to be the thin outer layer of the shell, in which there appears to be a prismatic structure, as seen by the aid of the microscope and a strong transmitted light. They show no flattened cardinal plate, but a furrow along the inner side of the hinge margin of each valve. The cardinal plate or area was doubtless composed, as in other cases, of the inner laminated portion of the shell, that has been destroyed during the fossilizing process; if not, it would seem to be a new genus.

Locality and position.—Division C of the Nebraska City section. It was likewise found in Mr. Morton's shaft, a short distance west of Nebraska City. Dr. White has also found it in the upper part of the

Middle Coal-Measures, and near the middle of the Upper Coal-Measures, in Iowa; and it occurs in the Upper and Lower Coal-Measures of Illinois at numerous places; also, in the Lower Coal-Measures of West Virginia.

AVICULOPECTEN WHITEI, Meek.

Pl. IV, Fig. 11 *a*, *b*, *c*.

Avicula—, Professor H. D. Rogers, 1858, Geological Report of Pennsylvania, Vol. II, p. 833, Fig. 689.

Shell truncato-suborbicular, thin, compressed, nearly or quite equivalve; length and breadth nearly equal; basal and anterior and posterior basal margins regularly rounded; posterior margin not sinuous above, but rather straight and intersecting the hinge at an angle of about 60° to 65°; hinge line nearly or quite straight, and generally a little less than the greatest breadth of the valves; posterior ear of both valves flat and somewhat alate, but not defined by any marginal sinus, nor separated from the umbones by any depression or sulcus; anterior ear of left valve small, nearly rectangular, or somewhat rounded, and defined by a shallow, subangular sinus; same in the right valve, nearly rectangular at the extremity, and defined by a rather deep, sharply-angular sinus, from which a shallow furrow extends obliquely up to the beak. Surface of both valves ornamented with rather irregular, obscurely-defined, depressed, and more or less flexuous radiating costæ, which are obsolete on the anterior ear and compressed posterior alation; lines of growth rather well defined, particularly on the ears and around the free borders.

Height (of one of the largest specimens), 0.67 inch; breadth of same, 0.76 inch.

This species is in some respects related to *A. rectilaterarius* of Cox, and *A. papyraceus* of Sowerby, but differs from them both in its surface markings, as well as in some other details. In general form it resembles *Aviculopecten* (*Meleagrina*) *echinatus*, McCoy (Carb. Fos. Ireland, p. 79, Pl. XIII, Fig. 18), but in that species the deep byssal sinus was in the left instead of the right valve, and its surface markings were different.

All the specimens of this species I have seen from Nebraska consist only of the extremely thin, outer apparently prismatic layer of the shell, and are compressed nearly flat in the shaly matrix, though they show the form and surface markings perfectly. They retain no traces of the cardinal plate, but that was probably composed of the laminated portion of the shell that is wanting in these specimens. I have seen others, from the Upper Coal-Measures of Iowa, apparently retaining both the inner and the outer layers of the shell, and hence thicker than those from Nebraska, though none of them were in a condition to show the hinge. I have some doubts whether it is a true *Aviculopecten*.

The specific name is given in honor of Professor C. A. White, the efficient State geologist of Iowa.

Locality and position.—Nebraska City, from a shaft sunk apparently to near the horizon of the outcrops seen at the landing there; also from near the same or a higher horizon at Brownville, on the Missouri; and from Middle Nodaway River, Iowa, in Upper Coal-Measures. It occurs in both the Upper and the Lower Coal-Measures of Illinois; and I suspect that it is the same shell figured by Professor Rogers from the Coal-Measures of Pennsylvania in his report cited; though it may be only an allied species.

AVICULOPECTEN COXANUS, M. & W.

Pl. IX, Fig. 2 *a*, *b*.

Aviculopecten Coxanus, Meek & Worthen, Proceed. Acad. Nat. Sci., Philad., Oct., 1860, p. 453; 1866, Illinois Geol. Report, vol. 2, p. 326, Pl. 26, Fig. 6 *a*, *b*.

Shell very small; thin, compressed, slightly oblique; broad subovate, exclusive of the ears; basal margin, rounded; anterior margin more or less rounded, rather straight and oblique above; posterior margin more prominent than the anterior, often sub-angular at the point where the postero-basal margin rounds up to meet the obliquely-sloping edge above. Hinge generally a little less than the greatest breadth of the valves below. Left valve with anterior ear of moderate size, flat, triangular, with the extremity generally a little less than a right angle, sometimes very slightly rounded, separated from the margin below by an abruptly rounded or sub-angular sinus; posterior ear slightly larger and much more acutely angular than the other, but shorter than the most prominent part of the margin below, from which it is separated by a moderately deep rather broadly rounded sinus; beak small, compressed, scarcely projecting beyond the cardinal margin, and placed a little in advance of the middle of the hinge; surface ornamented with linear, simple, often more or less flexuous costæ, which alternate in size, the smaller ones dying out at various distances between the free margins and the umbo —crossing all of these are numerous, extremely fine, regular, closely arranged concentric striæ, which, like the costæ, are more or less distinctly defined on the ears, as well as on the body of the valve. Right valve unknown.

Height of left valve, 0.37 inch; breadth of do. 0.39 inch; convexity about 0.05 inch.

The little shell I have here referred to *A. Coxanus* agrees well in size, general form and ornamentation, with the typical specimens of that species, excepting that it is a little more oblique than any examples I have seen from the Illinois locality. Yet I am not prepared to regard this as a specific difference, since the specimens vary more or less in this character.

These little shells are somewhat related to *Aviculopecten rectilaterarius* of Cox, and *Aviculopecten* (*Pecten*) *papyraceus*, Sowerby; but differ in being much smaller, and in having the posterior ear much more acute, in consequence of the deeper marginal sinus separating it from the posterior border below.

In all the specimens I have seen, the shell, or at any rate the only remaining portion of it, is extremely thin, and shows under the microscope the distinct appearances of prismatic structure. It is highly probable, however, that this is only the outer layer of the shell, and this may also account for the fact that the hinge shows scarcely any traces of the usual flattened and furrowed cardinal plate or area of the genus *Aviculopecten*; the cardinal margins being, as we now see the shell, apparently linear.

Locality and position.—Nebraska City, bed C; also in the Coal-Measures in Adams County, Illinois. It is worthy of note, that at the latter locality it is in the Lower Coal-Measures; while at Nebraska City it is found in the Upper. It also occurs in the Upper Coal-Measures of Illinois.

Genus AVICULOPINNA, Meek.

AVICULOPINNA AMERICANA, Meek.

Pl. IX, Fig. 12 *a*, *b*, *c*, *d*.

Avicula pinnæformis, Geinitz, 1866, Carb. und Dyas in Neb., p. 31, tab. II, Fig. 13; (not *Avicula pinnæformis*, Geinitz, 1857).
Aviculopinna Americana, Meek, 1867, Am. Jour. Sci. and Arts, Vol. XLIV, p. 282.

Shell small, compressed, with the slender elongated form of some of the Carboniferous species of *Pinna;* cardinal and ventral margins generally nearly straight (the latter being the more convex in outline) and converging gradually from behind to the rather obtusely pointed anterior extremity; posterior side truncated, rounding into the base, and intersecting the posterior extremity of the hinge very nearly at right angles—a little sinuous just below the extremity of the hinge. Cardinal margin so slightly convex in outline as to appear quite straight, very nearly equaling the greatest length of the valves, and provided with a well-defined marginal ridge, which narrows to a mere line, or dies out before reaching the beaks, and widens very gradually to the posterior extremity. Beaks nearly or quite obsolete, extremely oblique, and very slightly behind the very narrow, obtusely pointed, anterior extremity. Surface with two or three broad, nearly obsolete radiating ridges on the posterior dorsal region, and ornamented by numerous slender, very regularly disposed, and abruptly elevated lines or lamellæ, much narrower than the spaces between, and curving gracefully parallel to the posterior border; while on the basal half of the valves they are closely approximate and curve forward.

Length of the largest specimen seen, 1.35 inches; height of same, 0.43 inch; convexity, about 0.08.

Professor Geinitz identified this little shell with *Avicula pinnæformis*, Geinitz (=*Pinna prisca* of Munster). On comparing a good series of of specimens, however, with his figures and description of that shell given in his Dyas, of typical German examples, I was at once, without a shadow of doubt, led to regard the Nebraska shell as an entirely distinct species. Later comparisons with specimens of the same from German localities have also fully confirmed this conclusion. In the first place, it scarcely ever attains one-fourth the size of the foreign species, from which it differs entirely in the character of its surface-marking, in having its lamellæ of growth very regularly and abruptly elevated and arranged with great regularity, while they never form wrinkles along the lower side; nor are they and the spaces between crossed by any traces of the faint radiating lines, sometimes seen on the German species. It is also a proportionally much more compressed shell. Again our shell has its beaks *always* nearer the anterior extremity than *A. pinnæformis*, so much so, indeed, that it requires close looking, even in examining good specimens, to satisfy one that they are not really terminal. In fact, it was not until after examining a number of specimens that I ascertained from some of the internal casts that there is an almost minute lobe-like portion of the anterior extremity, projecting slightly beyond the beaks. Other important differences are the presence of a well-defined ridge along the dorsal margin of the Nebraska species, and its slightly sinuous posterior margin, by which it is made to intersect the cardinal edge at a right angle; while neither Professor Geinitz's figures, nor the specimens I have seen of the European form, show any traces of such dorsal marginal ridge, and they have the posterior margin, and marks of growth curving forward above so as to intersect the *cardinal margin at a decidedly* obtuse angle.

The impropriety of referring such a shell to the genus *Avicula* must be evident to every conchologist. At first I was inclined to place it in the genus *Pinna*, but on finding that its beaks, although *very* near the anterior extremity, are yet not exactly terminal, I became satisfied that it could not be properly referred to that genus, and referred it provisionally to the genus *Aviculopinna*, though later comparisons have led me to suspect that it may possibly be found to belong to McCoy's genus *Pteronites*, and have to take the name *Pteronites Americana*. It has the prismatic shell structure of the allied *Pinna* and *Avicula* groups.

Locality and position.—Division C, of the Nebraska City section. Dr. White has also found it associated with many of the same species of other fossils near the middle of the Upper Coal-Measures of Western and Central Iowa. I have not yet met with it at any locality further eastward, though it will probably be found in Illinois.

Genus PINNA, Linnæus.

PINNA PERACUTA, Shumard.

Pl. VI, Fig. 11, *a*, *b*.

Pinna peracuta, Shumard, 1858, Trans. St. Louis Acad. Sci. 1, p. 19.
——— *Adamsi*, McChesney, 1860, New Palæozoic Fossils, p. 74.

Shell thin, very narrow, elongated, and tapering gradually and regularly from the larger to the smaller extremity; convex or almost subcylindrical, excepting toward the posterior extremity, which is compressed and obliquely rounded, or subtruncated. Hinge margin very long, and almost perfectly straight—carinated in consequence of the sudden erection of the dorsal edges of the valves; ventral margin equally as straight as the dorsal, and ranging at an angle of about 12° with the latter. Surface nearly smooth, or only showing very obscure lines of growth.

I have never seen a complete specimen of this species, and hence cannot give accurate measurements. Some specimens, however, indicate a length of nearly 12 inches.

I know of no other American species with which this is liable to be confounded. Its smooth surface will at once distinguish it from the other described, narrow, elongated Carboniferous species of this country. I am much inclined to think an imperfect shell figured by Professor de Koninck (Anim. Foss. Pl. 5, Fig. 3), under the name *Solen siliquoides*, is a true *Pinna*, and related to this, though specifically distinct. Our shell, however, seems to be most nearly allied to *P. spatula*, McCoy, as figured in his Palæozoic Fossils, Pl. 3 E, Fig. 9-10, and may possibly be the same, though it seems to be straighter on the margins than McCoy's species.

Locality and position.—The specimen figured is from Bennett's Mill, three miles northwest of Nebraska City; it also occurs at Wyoming, on the Missouri, and at Nebraska City, in beds B, referred by Professor Geinitz and Professor Marcou to the lower part of the Upper Dyas. It likewise occurs at a lower position at Plattsmouth, Rock Bluff, Bellevue, and, in short, at numerous localities through the Coal-Measures of Iowa, Nebraska, Kansas, Missouri, Illinois, &c., &c.

Genus AVICULA (Klein), Brug.

AVICULA LONGA, Geinitz, sp.

Pl. IX, Fig. 8.

Gervillia longa, Geinitz, 1866, Carb. und Dyas in Neb., p. 32, Tab. II, Fig. 15.

Shell nearly or quite equivalve; body part obliquely elongated and more or less arcuate; posterior end narrow and abruptly rounded; base nearly straight and parallel to the cardinal margin behind, but ascending obliquely forward from near the middle of the valves; anterior side oblique, and broadly and faintly sinuous under the ear. Hinge line about three-fourths the length of the valves, and provided with a marginal ridge, produced behind into a very narrow, elongated ear, considerably shorter than the oblique body portion of the valves, from which it is separated by a deep sinus which narrows to an abruptly rounded or subangular extremity close under the ear; anterior ear shorter and much broader than the other, in the left valve convex, with its extremity pointed, and faintly sinuous just below the point—separated from the swell of the umbo by an oblique sulcus extending from the anterior side of the same to the back part of the broad, shallow marginal sinus defining the ear. Beaks of both valves convex, very oblique, placed one-fourth to one-fifth the length of the hinge back of the anterior extremity; in the right valve, rising little above the hinge, but in the left somewhat more prominent, according to Professor Geinitz's figures.

Length of medium-sized specimen, measuring obliquely from the extremity of the anterior ear to the posterior end of the body part of the valves, 0.61 inch; height, measuring at right angles to the hinge, 0.33 inch; length of hinge, about 0.23 inch.

Having seen the hinge-plate of Illinois specimens of this little shell, I am positively sure that it has not the peculiar cartilage pits of the genus *Bakevellia* or *Gervillia*, though some of the casts I have seen show that it has the hinge teeth of *Avicula*, to which genus I cannot hesitate to refer it.

I have not seen a left valve—all those before me from Nebraska City being right valves. In all of these there is, as represented in the figure given, a little short sulcus or indentation, extending nearly at right angles to the hinge, just in front of the beak. In Professor Geinitz's figure of a left valve, there would seem to be several of these little indentations. They are not cartilage pits, however, but are formed by pressure upon anterior teeth within, so as to show on the outside of the valves, and are not impressions in a cardinal area. I am not acquainted with any species with which this is liable to be confounded.

Locality and position.—The specimen figured is from division C of the Nebraska City section. While passing through Iowa with Dr. White, we found good specimens of it near St. Charles, Madison County, in the upper beds of the Middle Coal-Measures, directly associated with *Aviculopecten carboniferus* (=*Pecten Hawni* Geinitz), and various Lower Coal-Measure types. I also found it, at a considerable lower position than the Nebraska City beds, in the Coal-Measures at Riverside, three miles below Atchison, Kansas. It likewise occurs in the Upper, Middle, and Lower Coal-Measures of Illinois.

AVICULA? SULCATA, Geinitz.

Pl. IX, Fig. 9.

Gervillia (Avicula) sulcata, Geinitz, 1866, Carb. und Dyas in Neb., p. 33, Tab. II, Fig. 16.

I have seen no good specimens of this species, and consequently reproduce the figure given by Professor Geinitz. From his figure (of a left valve) it seems to be a subrhombic oblique shell, with a short, compressed, triangular anterior ear, defined by a faint, wide marginal sinus; and a larger compressed, somewhat alate, posterior ear, with a marginal ridge, showing a tendency to be produced into a narrow appendage behind, separated from the margin below by a rather deep rounded sinus. The posterior basal extremity is rather narrowly rounded, but not much produced; while the outline of the base is broadly semielliptical, and the umbo convex, and rising somewhat above the hinge line, which is apparently shorter than the greatest length of the valve. Surface ornamented behind by fine lines of growth, and before by two or three sulci, extending from the anterior side of the beak to the antero-basal margin, leaving ridges between, which are more or less crenated by the crossing of the marks of growth; just behind the posterior one of these sulci, the margin of the latter is ornamented with regular, rather strongly defined wrinkles or little folds, some of which are prolonged backward parallel to the lines of growth.

This must be a very handsome species, and is more probably an *Avicula* than a *Bakevellia;* but, as its hinge and cardinal area are unknown we have not the means of settling this question. I know of no similar species with which it might be confounded.*

Locality and position.—Bed C of the Nebraska City section.

Genus PSEUDOMONOTIS, Beyrich.

PSEUDOMONOTIS, sp.

Pl. II, Fig. 11.

This fragment agrees so exactly in its surface-marking (consisting of a larger series of flexuous costæ, with vaulted, scale-like projections and smaller, irregular, intermediate ribs) with shells of the genus *Pseudomonotis*, that I can scarcely entertain a doubt in regard to its belonging to that group. It is not sufficient, however, for specific identification, though it would not be difficult for those whose method of making paleontology easy leads them to include, under the single species *speluncaria*, all the known forms of this group, to see that species in it. So far as can be seen, however, it agrees well with some real or supposed varieties of the species *speluncaria*, and it may really belong to that species: and yet, a perfect specimen *might* show it to be quite different.

It may be proper to explain here that the genus *Pseudomonotis* was proposed by Beyrich in 1862 for the group typified by the species *Avicula speluncaria*, Munster. This shell had been for some time previous referred to Bronn's genus *Monotis*, from the type of which (*M. salinaria*) it differs very materially in its inequivalve character, and especially in having a deep, sharply defined byssal notch in the anterior margin of the right valve. On comparing one of these shells with specimens of

* NOTE.—Professor Geinitz has figured another form from Kansas on the same plate with the foregoing under the name *Gervillia parva*, M. & H., which I at one time believed to be a variety of our *Bakevellia parva;* but from such comparisons as I have been able to make of casts (in which condition only it is known to me) during the last three *or four years, I have* been led to the suspicion that it may be a distinct species.

Bronn's type in 1864, I was satisfied that they were not congeneric, and proposed the name *Gryphorhynchus* for the *speluncaria* group, not being at that time aware that Beyrich had previously proposed to separate it, upon exactly the same grounds, under the name *Pseudomonotis*. As the latter name has priority of date, of course it will have to take precedence.

Locality and position.—The fragment figured was found loose at the base of Cedar Bluff, on Weeping Water, twelve miles northwest of Nebraska City, composed of the same beds referred by Professor Marcou to the Lower Dyas, and by Professor Geinitz to the Coal-Measures, at Rock Bluff on the Missouri. As elsewhere explained, species of this genus occur in Kansas, Iowa, and Illinois, far down in the Coal-Measures, below the horizon of the Nebraska City beds.*

PSEUDOMONOTIS RADIALIS, Phillips ? ?, sp.

Pl. IX, Fig. 3.

? *Pecten radialis*, Phillips, 1834. Encyc. Meth., Vol. IV, Pl. III, Fig. 5.
? *Monotis radialis*, King, 1848, Catalogue, p. 9; 1850, Monogr. Perm. Foss., England, p. 157, Pl. XIII, Figs. 22, 23.
? *Aricula speluncaria*, Geinitz, 1866, Carb. und Dyas in Neb., p. 78; (not Münster).

Left valve small, oblong, higher than wide, moderately convex; basal margin regularly convex; posterior margin nearly straight along the middle, but rounding into the base below, and a little inclined forward above, so as to intersect the hinge at an obtuse angle, and form a slight, undefined, compressed posterior alation; anterior side rounding into the base below, and rather distinctly sinuous above, just beneath a short, round, lobe-like anterior ear; umbo not oblique, moderately convex, and rising very little above the cardinal margin, which is rather shorter than the breadth of the valve. Surface ornamented with fine, unequal, flexuous, radiating ribs, or striæ, more or less roughened, apparently by the crossing of little concentric markings, and a few larger wrinkles of growth; some of the costæ apparently terminating in little short spine-like projections at the base. (Right valve unknown.)

Height, 0.56 inch; antero-posterior diameter, 0.47 inch; convexity (left valve), about 0.13 inch.

I merely refer this form provisionally to *P. radialis*, more from a reluctance to attempt to name and describe a new species from a single valve in a genus like this, than from any strong impression that it is really idential with that form. It has much the general appearance of Professor King's Fig. 22, cited above, though its costæ are much finer and more crowded, and its anterior margin differs in being sinuous below the ear. These differences may or may not be specific, or the shell may even belong to another genus, as it is impossible to determine these questions without specimens, showing both valves, for a comparison.

Locality and position.—Division C of the Nebraska City section. It must be very rare, as only a single specimen was found.

Genus MYALINA, de Koninck.

MYALINA [?] SWALLOVI, McChesney.

Pl. IX, Fig. 7 *a*, *b*.

Myalina Swallovi, McChesney, 1860, Descriptions New Palæozoic Fossils, p. 57; and 1865, Pl. II, Fig. 6, illustrations of same; Meek & Worthen, Illinois Palæont. Report, p. 341, Pl. 27, Fig. 1.
? *Aucella Hausmanni*, Geinitz, 1866, Carb. und Dyas, in Neb., p. 25, Tab. II, Fig. 8; (not Goldfuss, 1834, sp).

Shell rather small, nearly or quite equivalve, modioliform or mytiloid, convex, or even subangular, along the umbonal slopes from the beaks to

* *Imperfect casts of perhaps the same species occur at Bennett's Mill.*

the anterior basal margin; posterior and postero-dorsal regions, cuneate; cardinal margin nearly straight, and about half the length of the shell, —passing almost imperceptibly, or without any angularity, into the posterior margin, which rounds down with a semicircular curve, to the narrowly rounded basal extremity; antero-basal margin ascending obliquely forward, more or less sinuous near the middle, or sometimes a little above, usually swelling out into a kind of lobe or protuberance above the middle in front of the umbonal slopes, as in *Modiola*. This prominence sometimes extends a little beyond the beaks, and varies more or less in breadth. Beaks small, very oblique, not projecting beyond the cardinal margin, and located so near the anterior extremity as often to appear very nearly terminal. Surface rather smooth, but showing fine concentric lines, which in well-preserved specimens are sometimes crossed by very fine, obscure traces of radiating striæ, that curve upward on the posterior dorsal region.

The specimens figured are of nearly natural size, but smaller than the average size of the species.

This species varies somewhat in the size of the protuberance under the beaks; in some individuals it is well developed, and gives the shell much the form of *Modiola;* while in others it is smaller, so as to present more the appearance of a *Mytilus*. The beaks, however, are rarely quite terminal. The radiating striæ mentioned in the description are very obscure, and may be easily overlooked, as they appear to be rather due to the texture of the shell than to true surface striæ, and in some cases they seem to be entirely obsolete. The cardinal plate, as seen in authentic specimens from Illinois, is quite narrow, and shows only obscure traces of one or two cartilage furrows. As I have also been unable to see any traces of a prismatic structure in the shell, there may be some reason for doubting whether it is a true *Myalina*.

The specimen figured by Professor Geinitz under the name *Aucella Hausmanni*, may possibly be a distinct species from this, but I have little doubt in regard to its being really an internal cast of this shell. That it is not an *Aucella*, however, I have no doubt whatever, that being a Jurassic genus, unknown in the Coal-Measures or Permian rocks, and presenting radical differences. Of a large collection now before me, from the same locality and position, the shell I have figured is the only one resembling that figured by Professor Geinitz. It never has any traces of the little anterior ear, and byssal emargination of *Aucella*.

Locality and position.—Bed C of the Nebraska City section. It is also widely distributed in the Upper and Lower Coal-Measures of Illinois, Kentucky, Iowa, Nebraska, Kansas, and Missouri.

MYALINA SUBQUADRATA, Shumard.

Pl. IV, Fig. 12; and Pl. IX, Fig. 6.

Myalina subquadrata, Shumard, 1855, Geol. Report Missouri Survey, p. 207, Pl. C, Fig. 17; Geinitz, 1866, Carb. und Dyas in Neb., p. 27, Tab. III, Fig. 25 and 26.
Compare *M. deltoidea*, Gabb, Proceed. Acad. N. S. Philad., Nov. 1859.

Shell large and thick, oblong or subquadrate, the height being greater than the antero-posterior diameter; right valve nearly flat; left convex, both somewhat compressed and alate above and behind the umbonal prominence. Hinge line nearly straight, about equaling the greatest breadth of the valves, and ranging at right angles to the vertical axis; basal margin regularly rounded; posterior margin nearly vertical, rounding into the base below, a little sinuous above the middle, and inter-

secting the hinge above at very nearly right angles; anterior margin thickened within, rounding into base, thence rising nearly vertically, with a broadly rounded concavity mainly above the middle. Beaks terminal and directed forward. Cardinal plate or area usually rather broad, with cartilage furrows distinctly defined. Surface of left valve marked with fine concentric striæ, and stronger imbricating lamellæ of growth. These markings are much less distinct on right valves.

A fully developed specimen of this species, from the original locality on the Missouri near the mouth of Nemaha River (from which locality Dr. Shumard's typical specimens were obtained), measures about three inches in height from the base to the hinge margin, and 1.90 inches in breadth.

This is one of the largest species of the genus known. We did not succeed in finding examples of it in division C at Nebraska City, excepting in the condition of mere fragments, and hence I have copied Professor Geinitz's figure of a specimen from that horizon on Pl. IX. Fig. 11, Pl. IV, however, represents an impression, with portions of the thin outer fibrous layer, of a fully mature specimen, as seen in the matrix, taken from Mr. Morton's shaft, one and three-quarter miles west of the Nebraska City landing. It is widely distributed in the Upper Coal-Measures of Iowa, Nebraska, Kansas, Illinois, &c.

The large species figured by Dr. Hayden and the writer on p. 33, of the Palæontology of the Upper Missouri as *M. subquadrata*, is, as we then suspected, a distinct species, differing in having the posterior margin rounding forward into the hinge above, and not sinuous or meeting the hinge at right angles, as in *M. subquadrata*. It will have to take the name *M. ampla*, suggested by us for it in case it should be found distinct. It and *M. deltoidea* of Gabb, are the only forms resembling *M. subquadrata* with which I am acquainted; and the latter may be only a variety of Shumard's species.

The outer layer of *M. subquadrata* is so coarsely prismatic that its structure can be readily seen, when well preserved, by the aid of a common pocket lens.

Locality and position.—The specimen figured by Professor Geinitz, is from division C of the Nebraska City section. We also have it from division B of that place, and Bennett's Mill; and from Bellevue, in lower positions of the Coal-Measures; likewise from apparently a higher position a short distance west of Nebraska City.

Genus NUCULA, Lamarck.

NUCULA BEYRICHI, v. Schauroth?

Pl. X, Fig. 18.

? *Astarte Geinitziana*, Liebe, 1853, Leonhard u. Bronn, Jahrb., p. 773; (without description).

? *Nucula Beyrichi*, v. Schauroth, 1854, Zeitschr. d. Deutsch. geol. Gess., VI, p. 551, Tab. 21, Fig. 4; Geinitz, 1861, Dyas, p. 67, Tab. XIII, Fig. 22–24; also 1866, in Carb. und Dyas in Neb., p. 21, Tab. 1, Fig. 36–37.

Comp. *Nucula parva*, McChésney, 1860, Descr. New Palæozoic Foss., p. 54; and illustrations same, 1865, Pl. 2, Fig. 8 *a*, *b*, *c*.

Shell very small, longitudinally subovate, moderately convex, widest posteriorly;* anterior end somewhat narrowly rounded; base forming a semiovate curve, the most prominent part being near the shorter end; posterior side very short, comparatively wide, and subtruncated; beaks near the posterior extremity; hinge-line nearly rectangular at the

* *In true Nucula, the longer* side is the anterior.

beaks; denticles comparatively large, about seven on the longer side, and five or six on the shorter; surface marked with moderately distinct regular concentric striæ.

Length, 0.16 inch; height, 0.10 inch.

It is with very great doubt that I have referred this little shell to *N. Beyrichi*, as I only know it from a single specimen, consisting mainly of an internal cast. There is also room for some doubt whether it is the same form referred by Professor Geinitz to *N. Beyrichi*, from the same locality and position. Unless Professor Geinitz's specimens were distorted or incorrectly drawn, I should think his a different species, both from that described above and from the true *N. Beyrichi*. The form described above agrees in size, and tolerably nearly in outline with German examples of von Schauroth's species now before me, or at least with specimens sent to the Smithsonian Museum with that name attached. It differs from von Schauroth's description in having only some seven, or possibly eight, hinge-teeth behind the beak, and five or six in front, instead of twelve of the former and seven of the latter.

In order that others may have some means of forming their own conclusions in regard to the relations of these shells, I have given an enlarged figure of the form described above, and copies of two of Professor Geinitz's figures (see our Pl. X, Fig. 19 *a*, *b*) of the Nebraska shell, referred by him to *N. Beyrichi*. On the same plate (Fig. 25 *a*, *b*, *c*), I have also given copies of von Schauroth's original figures of his species, and of Professor Geinitz's figures of German examples of the same (Fig. 24 *a*, *b*); likewise, figures, natural size and enlarged, drawn directly from a foreign specimen sent to the Smithsonian Institution, labeled *N. Beyrichi*. (See Fig. 23 *a*, *b*.)

Locality and position.—Division C of the Nebraska City section. An undistinguishable form also occurs in the Coal-Measures of Illinois; while another form described from Illinois by Professor McChesney, under the name *N. parva*, is also closely related, though apparently distinct.

NUCULA VENTRICOSA, Hall.

Pl. X, Fig. 17 *a*, *b*, *c*.

Nucula ventricosa, Hall, 1858, Iowa Report, I, Part II, Pl. 716, P. 29, Fig. 5 *a*, *b*.
Compare *N. tumida*, Phillips, 1835, Geol. Yorksh., p. 20, Pl. V, Fig. 15.

Shell small, thick, subovate, very convex; the greatest convexity slightly in advance of the middle of the valves; posterior (shorter) end obliquely truncated from the beaks to its narrowly rounded or subangular connection with the base, rather deeply excavated just behind the beaks; anterior (longer) end rather narrowly rounded, its most prominent part being near or slightly above the middle; dorsal outline declining gently, with moderate convexity from the beak to the anterior extremity; basal margin forming a nearly semiovate curve, being a little more prominent before than behind the middle; beaks convex, rather prominent, and placed about half-way between the middle and the most projecting part of the postero-ventral extremity. Surface with (at least near the base) fine, regular, concentric striæ.

Length, 0.42 inch; height, 0.28 inch.

The only specimen of this little shell in the collection is incrusted by calcareous matter, so as to obscure the surface striæ, excepting near the lower margin; hence the striæ, on other parts of the figures given, are restored. It is therefore barely possible that the more convex portions of the valves may be smooth, or nearly so.

It is possible that the last-described form may be only the internal cast of this. If so, I could have no doubts in regard to the species being entirely distinct from *N. Beyrichi*, since its form is altogether different.

Although this shell differs slightly in outline from the particular specimen of *N. ventricosa*, figured in the Iowa Report, a comparison with a series of specimens of that species (which varies more or less in outline) leaves little room to doubt the identity of our shell with *N. ventricosa*. It is also proper to remark here that after comparing good specimens of *N. ventricosa* from the Coal-Measures of Illinois with examples of a shell sent to Mr. Worthen by Mr. Thomas Davidson, of Brighton, from Carluke, Scotland, with the name *N. tumida*, Phillips, attached, no satisfactory differences were observed.

Locality and position.—Division C of the Nebraska City section: also, at Rock-Bluff, in bed 6, of the section at that place. This species is common all through the Coal-Measures of Illinois; and I have identified it among Lower Coal-Measure species from West Virginia, collected by Professor J. J. Stevenson, of Morgantown, in that State.

Genus YOLDIA, Möller.

YOLDIA SUBSCITULA, M. & H. ?

Pl. X, Fig. 10.

Leda subscitula, Meek & Hayden, 1858, Trans. Albany Inst., Vol. IV.*
Yoldia ? subscitula, M. & H., 1864, Palæont. Upp. Mo., Part 1, p. 60, Pl. II, Fig. 4, *a. b.*
Nucula (*Leda*) *subscitula?* Geinitz, 1866, Carb. und Dyas in Neb., p. 22, Tab. 1, Fig. 35.

Shell longitudinally subovate or subelliptic, compressed, the greatest convexity a little in advance of the middle, about twice as long as high; anterior extremity wider than the other, but rather narrowly rounded, the most prominent point being usually slightly above the middle; outline of base forming a broad semiovate curve, being more prominent anteriorly than behind; posterior side narrowed, its margin rounding up gradually from the base, so as to meet the dorsal margin nearly at right angles, sometimes faintly truncate at the immediate extremity; posterior dorsal margin compressed or cuneate, and declining gradually, with a nearly straight, or slightly concave outline; anterior dorsal margin not cuneate, sloping forward gradually, and a litle convex in outline; beaks rather depressed and subcentral, or very little in advance of the middle; umbonal slopes without any defined ridge or angle. Surface smooth, or only showing traces of very minute concentric striæ.

Length, 0.77 inch; height, 0.37 inch; convexity, about 0.14 inch.

It is with considerable doubt that I have concluded to refer this shell to *Y. subscitula*, M. & H., because the specimens from Nebraska City are distinctly more compressed than the type upon which that species was founded, their convexity being uniformly not more than half as great proportionally. The five or six individuals in the collection are constant in this character, and yet show no evidences whatever of accidental compression. Otherwise the two forms are *very* similar in their general outline, but we know nothing of the internal and hinge characters of the form under consideration. I strongly suspect, however, that it will be found to be a distinct species, in which case I would propose to call it *Yoldia propinqua*, from its near resemblance to *Y. subscitula*. Of course

* This paper was issued in the form of extras on 4th March, 1858, some time in advance of the volume.

it is only placed provisionally in the genus *Yoldia*, its internal characters being unknown. It agrees exactly, however, in all external characters with that genus, and has a crenated hinge.

Professor Geinitz's figure of this shell is slightly defective (that is, supposing it to represent the same species, of which there is scarcely any reason to doubt, as it agrees in other respects, and was taken from a specimen from exactly the same locality and position) in having the posterior margin rounding into the hinge instead of meeting it at a more or less obtuse angle; this may have resulted from a slight imperfection of his specimen.

I have described, from the Lower Coal-Measures of West Virginia, in the Third Annual Report of the Regents of the University of that State for 1870, under the name *Y. Stevensoni*, another very closely allied species, only distinguished by having rather distinct, regularly disposed lines and furrows of growth.

Locality and position.—Division C of the Nebraska City section, Nebraska City.

Genus NUCULANA, Link.

NUCULANA BELLISTRIATA, *var.* ATTENUATA.

Pl. X, Fig. 11 *a*, *b*.

Leda bellistriata, Stevens, 1858, Am. Jour. Sci. and Arts, Vol. XXV, p. 261; Hall, 1858, Iowa Report, Vol. 1, Part II, p. 717, Pl. XXIX, Fig. 6.

Nucula Kazanensis, Geinitz, 1866, Carb. und Dyas in Nebr., p. 20, Tab. 1, Figs. 33 and 34; (not *Nucula Kazanensis*, de Verneuil ?, 1845).

Shell longitudinally subovate, moderately convex, or rather gibbous in the umbonal and anterior regions, as well as along the posterior umbonal slopes; basal margin semiovate; anterior margin more or less narrowly rounded; posterior very attenuate, and, at the extremity, subangular; umbonal ridge well defined; cardinal margin behind the beaks slightly concave in outline, carinate, and sloping backward, with a rather distinct, broad concavity or impression between it and the umbonal ridge, in front of the beaks, sloping more abruptly with a convex outline; beaks moderately prominent, and located generally about two-fifths the entire length of the valves behind the anterior margin. Surface ornamented with very fine and regular, concentric striæ, which become obsolete on the posterior umbonal ridges.

Length, 0.42 inch; height, 0.20 inch; convexity, 0.10 inch.

The specimens of this little shell yet obtained from Nebraska are smaller and more pointed behind than in the average adult size of *N. bellistriata* from the typical localities in Illinois, as well as rather more finely striated, but they agree so closely in form and general appearance as to render their identity with that shell almost certain. I have not seen any specimens from the Nebraska localities showing the hinge, but Dr. Stevens describes the Illinois specimens as having "about twenty-five teeth, five of which are smaller than the others, and clustered under the beaks."

Whether Professor Geinitz is right in referring this species to *N. Kazanensis* of Verneuil, is a question I have not the means of determining, only knowing that shell from figures of moulds of the exterior left in the matrix. If I may form an opinion from these figures, I should say that it is very similar to our shell, but scarcely more so than to Illinois specimens, from the typical localities in the Coal-Measures of that State. If the smaller size of the Nebraska specimens should be an objection to their being specifically identical with *N. bellistriata*, it should be remembered that this objection will equally apply to their

reference to the Russian species, which is very nearly of the same size as the typical Illinois specimens of *N. bellistriata.*

Supposing the published figures of *N. parunculus*, v. Keyserling, and *N. Kazanensis*, de Verneuil, to be even nearly correct, I must differ widely from Professor Geinitz in regard to their representing the same species. Indeed, it is rarely the case that two species of this genus are more unlike, even if we compare recent and Carboniferous species. The *N. parunculus*, if correctly represented, is *certainly* distinct from the Nebraska and Illinois shell, which, although varying somewhat, never assumes the form of Count von Keyserling's species.

Locality and position.—Division C of the Nebraska City section; also at a lower position in the Coal-Measures at Leavenworth, Kansas, and various localities in Iowa, Illinois, &c. I have likewise identified *precisely* the same smaller and more attenuate variety of this shell among specimens sent by Professor Stevenson from the Lower Coal-Measures of West Virginia.

Genus MACRODON, Lycett.

MACRODON TENUISTRIATA, M. & W.

Plate X, Fig. 20 *a*, *b*.

Macrodon tenuistriata, Meek & Worthen, 1867, Proceed. Chicago Acad. Sci., I, p. 17.
Arca striata, Geinitz, 1866, Carb. und Dyas in Neb., p. 20, Tab. 1, Fig. 32; (not *Mytilites striatus*, Schloth., 1817,=*Arca striata*, V. Schauroth, 1856).

Shell small, rhombic-oblong, rather distinctly convex, along the umbonal slopes, and near the front, a little more than twice as long as high; basal and cardinal margins parallel; the former nearly straight, or somewhat sinuous near the middle; cardinal margin straight, not quite equaling the greatest antero-posterior diameter; anterior side rounding up from below so as to meet the hinge nearly at right angles; posterior basal margin narrowly rounded; posterior margin obliquely truncated, often a little sinuous above; dorsal region behind the umbonal slope compressed; beaks convex, a little flattened, incurved, and rising somewhat above the hinge margin, located about half-way between the middle and the front; flanks broadly impressed or concave from the umbonal regions obliquely backward to the faintly sinuous part of the base; cardinal area unknown; posterior linear teeth about three; surface ornamented with distinct marks of growth crossed by radiating markings, which on the compressed posterior dorsal region form rather well-defined radiating lines; anteriorly, however, these diminish in size so as to become very minute or scarcely visible, crowded, obsolescent striæ.

Length, 0.75 inch; height, 0.31 inch; convexity, about 0.30 inch.

Professor Geinitz has identified this with the well-known *M. striatus* (= *Mytilites striatus* of Schlotheim). It may be at once distinguished from that species, however, by its costæ becoming mere minute obsolescent striæ on the middle and anterior portions of the valves. In order that the student may have the means of making the comparison for himself, I have also given, on the some plate, Fig. 27, an exact copy of Professor Geinitz's figure of the *M. striatus*, from the Permian rocks of Germany, given in his "Dyas," Taf. XIII, Fig. 33 *a*, from which our shell differs in so many points that I think there can be but one opinion among paleontologists generally, in regard to these shells being clearly distinct species. I do not wish to disguise the fact, however, that *M. striatus* (or at least forms referred to it) varies in the size of the radiating costæ, some of them having *the ribs* not more than half as large as

those of the example copied from Professor Geinitz. An examination of good European specimens, as well as of all the published figures, shows that they are always as coarse (and generally even more so) on the anterior part of the valves as behind, and never become mere minute lines on any part of the valves, while there are other differences not to be overlooked.

The surface markings mentioned, together with its much less ventricose form, will also distinguish our shell from *M. tumidus*(=*Bysso-arca tumida*) of Sowerby. From *Macrodon carbonarius*(=*Arca carbonaria*), Cox, it will be at once distinguished by its finer radiating striæ, and its beaks being placed less nearly over the anterior margin.

Locality and position.—Division C of the Nebraska City section. It also occurs in the Upper Coal-Measures of Springfield, Illinois, and at other localities of that State in the Lower Coal-Measures. Dr. White has likewise found it in the Upper Coal-Measures of Western Iowa.

Genus SCHIZODUS, King.

SCHIZODUS CURTUS, M. & W.?

Pl. X, Fig. 13 *a*, *b*, *c*, (*d*?) *e*.

Schizodus curtus, Meek & Worthen, 1866, Proceed. Chicago Acad. Sci., 1, p. 18.
? ——*Rossicus*, Swallow, 1858, Trans. St. Louis Acad. Sci., 1, p. 193.
——*Rossicus*, Geinitz, 1866,Carb. und Dyas in Neb., p. 18, Tab. 1, Fig. 28; (not *S. Rossicus*, de Verneuil?)
Comp. *Sch. rotundatus*, Brown sp., 1841, as figured in King's Perm. Foss., England, Pl. XV, Fig. 30.

Shell small, suborbicular, rather compressed, thin; anterior side obliquely subtruncated, with a convex outline above, and rounded into the base below; base deeply rounded anteriorly, and ascending with a slightly straightened outline, or even sometimes very faintly sinuous behind; posterior side narrower than the front, nearly vertically truncated, so as to form almost a right angle with the base at the termination of the umbonal ridge, and more or less rounding into the cardinal margin above; posterior dorsal region behind the umbonal ridge compressed and cuneate; cardinal margin sloping more or less behind the beaks; beaks elevated, incurved, and placed very slightly in advance of the middle; umbonal slope rather distinctly angular from the beak to the posterior basal extremity; flanks just in advance of this ridge sometimes faintly concave; surface marked with very fine concentric striæ.

Length of the largest specimen of the form from which the above description was drawn up, 0.43 inch; height, 0.38 inch; convexity, about 0.16 inch.

The foregoing description was made out from a fine series of specimens from Nebraska City, but this shell agrees so nearly with *S. curtus* from the Coal-Measures of Illinois (see Fig. 13, *e*, *f*, *g*, of same plate, given for comparison from an Illinois specimen from the original locality), that nearly every word of the description would apply equally well to that shell; the only differences being in the slightly straighter and more sloping posterior margin, and greater convexity of the Illinois shell. The latter character, however, is almost certainly due to the accidental compression of the Nebraska specimens, all of which, when carefully examined, show minute cracks on each side of the beaks, evidently produced by accidental pressure. The Illinois specimens being perfectly preserved, with the substance of the shell remaining, show the surface striæ rather more distinctly than those from Nebraska, which are cast

of the exterior. Without intending to express a positive opinion in regard to the relations of these two forms, I have concluded to refer the Nebraska City specimens provisionally to *S. curtus*.

In regard to both of these forms being distinct from *S. Rossicus*, however, *provided the figures given in the Geology of Russia are exact and represent normal forms of that shell*, I think there is much less room for doubt. On comparison with these, Figs. 21 *a* and 21 *b*, which I have reproduced for that purpose, particularly Fig. 21 *a*, which is the typical form of *S. Rossicus*,* it will be seen that the Nebraska shell has the beaks much more prominent, and the antero-ventral region much more deeply rounded, while its posterior margin is more nearly vertically truncated. Its posterior basal margin is also more angular in outline. Now, in all these characters the Nebraska shell is *very* constant. It is true there is another associated form, of which all of the few specimens I have seen are larger. This (see Fig. 13 *d*) I think almost certainly a distinct species, having seen no intermediate forms.

The shells here described, including both the Nebraska and Illinois specimens, are certainly *very* closely allied to *S. rotundatus* of Brown, and if identical with any European shell I should think would have to be referred to that species.

The drawings I have given are made with great care, and all the points of difference mentioned above and represented in the figures, both from the specimens and the figures reproduced for comparison, may be relied upon.

Locality and position.—The specimens represented by Fig. 13 *a*, *b*, *c*, and *d*, are from division C of the Nebraska City section. That represented by Fig. 13 *e*, *f*, *g*, is from the Wabash cut-off, Illinois Upper Coal-Measures. I also have somewhat larger specimens, agreeing nearly with the latter, from the Coal-Measures near Atchison, Kansas. The same form is likewise found in the Lower Coal-Measures of Illinois. According to Eichwald, however, *S. Rossicus* occurs both in the Carboniferous and Permian rocks of Russia.

SCHIZODUS WHEELERI, Swallow, sp.

Pl. X, Fig. 1 *a*, *b*, *c*, *d*, (and *e*, *f*?).

Cypricardia ? Wheeleri, Swallow, 1862, Trans. St. Louis Acad. Vol. I, p. 96.
Schizodus obscurus, Geinitz, 1866, Carb. und Dyas in Nebraska, p. 20, Tab. I, Figs. 30 and 31; (not Sowerby, 1821).

Shell attaining a medium size, longitudinally subovate, moderately convex; anterior side wider than the other, and regularly rounded; posterior side narrowed, and obliquely truncated; basal outline rather prominently rounded anteriorly, and straightened, or slightly sinuous between the middle, and sharply rounded or subangular posterior basal extremity; dorsal margin straight, and sloping from the beaks to the truncated posterior edge; beaks rather depressed (for a species of this genus), incurved, and placed about half-way between the middle and the front, or perhaps nearer the middle; posterior umbonal slope rather prominent, or usually forming a rather obtuse ridge near the posterior basal extremity; surface with merely fine lines and obscure marks of growth.

Professor Swallow's typical specimen of *Cypricardia ? Wheeleri*, according to a tracing he permitted me to make from his drawing, measures 1.15 inches in length, and 0.81 inch in height.

* The other figure, 21 *b*, is said not to be exactly correct, and besides may belong to another species.

It is possible the shell described under the above name by Professor Swallow may be distinct from those figured by Professor Geinitz, as the hinge and interior of the two cannot be compared; yet the tracing of the *S. Wheeleri*, as may be seen by Fig. 1 *b* of Plate X, is so nearly like Professor Geinitz's figures (one of which I have also copied on the same plate (Fig. 1 *a*), that I can scarcely doubt their identity.

Figures 1 *c*, *d*, of Plate X, represent the exterior and interior, hinge, &c. of a beautiful specimen, apparently of the same shell, from the Upper Coal-Measures of Adams County, Iowa, kindly loaned to me by Dr. White, the Iowa State geologist. Figures 1 *e* and 1 *f* of the same plate, represent an internal cast of a larger specimen, also loaned by Dr. White, from the Upper Coal-Measures of Union County, Iowa. Although the latter is larger, and differs slightly from the outline of Professor Geinitz's figures, if we make allowance for its larger size and for the fact of its being an internal cast, I see no very satisfactory reason for regarding it as a distinct species, though it may be so. At any rate, all of these four shells—that is, the typical *S. Wheeleri*, the one figured by Professor Geinitz, and the two from Iowa—differ more decidedly from the published figures of *S. obscurus*, to which Professor Geinitz refers the Nebraska City specimens, than they do from each other. For instance, it will be observed that they all have the umbones less prominent and less ventricose than is represented in the published figures of *S. obscurus;* while they all, both in internal casts and testiferous specimens, present a straightness of the posterior dorsal slope, and a distinctly truncated outline of the anal margin, never yet represented, so far as I have been able to see, in *S. obscurus*. In most of these points of difference, it will be observed that these shells agree more nearly with a form figured by Professor King, under the name *S. Schlotheimi*, Geinitz, on Plate XV, Fig. 32 of his Monograph of the English Permian fossils. Professor Geinitz, however, thinks this specimen figured by Professor King does not belong to his *S. Schlotheimi*. It certainly looks very unlike any of those figured by Professor Geinitz under that name in his work on the German Permian fossils, although the figures there given under the name *S. Schlotheimi* represent at least three forms differing much more widely from each other than the Nebraska and Iowa shells differ from each other, or from the typical *S. Wheeleri* of Swallow.

Until these shells can be better known, I have preferred to refer them, provisionally, to Professor Swallow's species, and at the same time to give figures of the several types, so that others can have the means of forming their own conclusions on these points.

Locality and position.—Professor Swallow's type of *S. Wheeleri* is from the Upper Coal-Measures of Caldwell County, Missouri. The specimens figured by Professor Geinitz are from division C of the Nebraska City section; and those I have figured from Iowa came from Adams and Union Counties, where they were found by Dr. White near the middle of the Upper Coal-Measures, associated with many of the same fossils found in division C of Nebraska City. All of these forms also occur in the Coal-Measures of Illinois.

SCHIZODUS, undt.

Pl. X, Fig. 2.

Of this form I have seen but a single specimen, consisting of an external cast of one valve. In its general outline it is decidedly more like *S. obscurus* than that figured by Professor Geinitz under that name *from the same* bed at Nebraska City; and yet it seems to differ from

the latter, as well as from *S. obscurus*, in being more compressed. It will also, on comparison, be at once seen to differ from the other Nebraska City specimens, as well as from those from Iowa, in having its umbones more elevated and its anterior ventral margin more deeply rounded in outline. Without other specimens for comparison, I would not be willing to refer it to *S. obscurus*, nor yet to name it as a new species.

It is also worthy of note that the form under consideration is quite as nearly like one of the specimens figured by Professor Geinitz on Plate XIII of his work on the Permian fossils of Germany, under the name *S. Schlotheimi*, though quite unlike the others. I mean his Figure 12 of the plate referred to. Not having access to his original description of the *S. Schlotheimi*, I do not know which of the forms he has figured on the plate above cited is the type of that species.

Locality and position.—Division C of the Nebraska City section.

Genus MODIOLA, Lamarck.

MODIOLA? SUBELLIPTICA, Meek.

Pl. X, Fig. 5.

Clidophorus (Pleurophorus) occidentalis, Geinitz, 1866, Carb. und Dyas in Neb., p. 23, Tab. II, Fig. 6; (not *Pleurophorus occidentalis*, M. and H., 1858).

Pleurophorus subellipticus, Meek, 1867, Am. Jour. Sci. and Arts, Vol. XLIV, new series, p. 181.

Shell narrow, subelliptical, rather convex, extremely thin, usually a little more than twice as long as high; basal margin nearly straight, or sometimes very slightly convex or sinuous near the middle, rounding up at each extremity; anterior margin narrowly rounded; posterior extremity more compressed, and more broadly round, sometimes a little oblique above; cardinal margin somewhat straightened along the middle but rounding imperceptibly into the anterior and posterior extremities; beaks much depressed, or scarcely distinct from the cardinal margin, moderately convex and placed very near the anterior margin, but not terminal; umbonal slopes forming a very obscure narrow ridge, which extends, with a slight curve from each umbo, to the posterior basal margin. Surface marked with moderately distinct lines of growth, which on the posterior dorsal rigion above the umbonal ridge, are crossed by very minute or microscopic radiating and rather distinctly divaricating striæ.

Length of largest specimen seen, 1.03 inches; height of same, 0.45 inch; convexity, about 0.25 inch.

Professor Geinitz referred this species to *Pleurophorus occidentalis*, M. and W., but it is a widely distinct shell, differing greatly in having its beaks scarcely distinct from the cardinal margin, instead of prominent and nearly terminal. It also differs in the outline of its dorsal margin, which is concave in *P. occidentalis;* while the latter is a much thicker shell. Indeed, a careful examination of a good series of specimens, obtained from Nebraska City by Dr. Hayden's survey, since the publication of my review, in the American Journal of Sciences, of Professor Geinitz's work on the Nebraska fossils, has clearly satisfied me that this shell is not a *Pleurophorus* at all, as its internal casts show no traces of the posterior hinge teeth or internal ridges of that genus. Its general form and divaricating minute radiating striæ, depressed beaks, &c., seem to indicate affinities to some of the sections of the genus *Modiola*, though it may possibly be found to fall into the genus *Cardiomorpha*, and have to take the name *C. subelliptica*, or into *Modiomorpha* and have to be called *M. subelliptica.*

Locality and position.—Division C of the Nebraska City section; also at a lower position in the Coal-Measure at Riverside, three miles below Atchison, Kansas.

Genus PLEUROPHORUS, King.

PLEUROPHORUS OBLONGUS, Meek.

Pl. X, Fig. 4 *a*, *b*, *c*.

Pleurophorus Pallasi, Geinitz (pars), 1866, Carb. und Dyas in Neb., Tab. II, Fig. 4; (not *Modiola Pallasi*, de Vern., 1845).

Shell small, longitudinally oblong, about twice as long as high, moderately convex, particularly along the umbonal slopes from the beaks to the posterior basal margin, but without any defined angle or ridge there; cardinal margin nearly straight, and subparallel to the base, about equaling two-thirds the entire length of the valves; basal margin more or less distinctly sinuous near the middle, at the termination of a broad, oblique impression or concavity extending from the anterior side of the beaks under the umbonal slopes to the lower margin; anterior margin narrowly rounded below; posterior side much wider, rounded, or sometimes obliquely subtruncated above; beaks convex, very oblique, obtuse, located one-seventh to one-eighth the length of the valves behind the anterior extremity; surface with apparently only fine concentric marks of growth; muscular impressions faintly marked; ridge behind the anterior one small; posterior lateral tooth slender and elongated.

Length of largest specimen seen, 0.44 inch; height, 0.24 inch; convexity, about 0.14 inch.

Although this shell resembles in external characters some of the short varieties of the so-called *Pleurophorus Pallasi*, from the Russian Permian rocks, I cannot agree with Professor Geinitz in referring it to that species, because some of the internal casts before me show that the Nebraska shell has a distinct, elongated, linear posterior-lateral tooth, as we see in true *Pleurophorus;* while the Russian species is both figured and described as being "completely edentulous," and is consequently not a *Pleurophorus*, but more probably a *Cardiomorpha.* In addition to this, our shell has a much straighter and proportionally longer hinge, is not, so far as yet known, so variable in form, and has its anterior muscular impression defined by a weaker and less oblique ridge.

I am also compelled to differ with Professor Geinitz in regard to the identity of this and the form represented by his Fig. 3 of the same plate; and as I have elsewhere stated, more decidedly, in regard to the latter being identical with the Russian species *Pallasi*, from which I believe it to differ generically.

Locality and position.—Division C of the Nebraska City section.

PLEUROPHORUS OCCIDENTALIS, M. & H.?

Pl. X, Fig. 12.

Pleurophorous occidentalis, Meek & Hayden, 1858, Trans. Albany Inst., IV; 1864, Palæont. Upper Missouri, p. 35, Pl. I, Fig. 11 *a*.*

Clidophorous Pallasi, Geinitz (pars), 1866, Carb. und Dyas in Neb., p. 23, Pl. II, Fig. 3; (not *Mytilus Pallasi*, de Vern., 1845).

Internal cast small, narrow-oblong, moderately convex along the umbonal slopes; basal and dorsal margins nearly straight and sub-parallel,

* This figure is very imperfectly lithographed, the outline of the base being made too convex, and the anterior basal margin ascends too obliquely.

or converging slightly forward; posterior side wider than the anterior, rather compressed, obliquely sub-truncated above and narrowly rounded below; anterior side very short and rounded; beaks very oblique, located almost directly over the anterior extremity; posterior dorsal region, with three oblique radiating ridges, extending from behind the beaks to the anal margin, the lower one forming the umbonal ridge; below the latter traces of two or three much smaller radiating linear marks are seen; impression of posterior lateral hinge tooth distinct along the cardinal margin; internal ridge bounding the anterior muscular scar, well defined and ranging nearly vertically.

Length, about 0.46 inch; height, 0.24 inch.

It is not without some doubts that I have referred this form, which I only know from Professor Geinitz's figure of an internal cast (copied on Pl. X, Fig. 12), to *P. occidentalis*, M. & H., though strongly inclined to believe it the same. It is much more like that species than the figure of it given in our Palæontology of the Upper Missouri would lead one to suppose, the error in the engraving giving the shell too much of a pointed appearance anteriorly. When allowance is made for this fault in the engraving, and it is borne in mind that Professor Geinitz's figure represents an internal cast, and that the thickened shell in the region of the umbones must have made the beaks look much more prominent than in the cast, it will be understood that the form under consideration must have closely resembled *P. occidentalis.*

Whatever may be its relations to that shell, however, it seems to me very clear that it must be widely distinct, as I have elsewhere shown, from the so-called *Mytilus Pallasi*, de Verneuil, which, as already stated, is both figured and described as a "completely edentulous" shell; while that under consideration, as shown by the cast, has the long posterior lateral tooth, as well as the general physiognomy of true *Pleurophorous.* In short, as suggested by Professor King, the so-called *Mytilus Pallasi*, has the hinge characters of *Cardiomorpha;* but whether a *Cardiomorpha* or not, it can scarcely be possible that it belongs to the same genus as the shell under consideration.

I should be much more inclined to think our shell identical with *Pleurophorus costatus*, Brown, than with the *M. Pallasi;* for on comparison with Professor King's figures of that species (Perm. Foss., England, Tab. XV, Figs. 13 and 14), they will be seen *very* closely to resemble it.

Locality and position.—The typical specimens of *P. occidentalis* were from the Upper Coal-Measures in Otoe City, Nebraska, opposite the northern boundary of Missouri. The specimen figured by Professor Geinitz, and copied on Plate X, was found in division B of the Nebraska City section. I have also seen the same shell from the Upper Coal-Measures of Illinois, at Grayville.

Genus EDMONDIA, de Koninck.

EDMONDIA REFLEXA, Meek.

Pl. X, Fig. 6, *a*, *b;* and Pl. IV, Fig. 7.?

Shell sub-elliptical, the length being about twice the height, moderately convex in the umbonal and central regions, but without any defined anterior or posterior umbonal ridges; basal margin forming a broad, sem-ielliptic curve; anterior and posterior extremities subequally rounded; dorsal margin somewhat straightened along the middle, but rounding into the extremities, *without* a defined escutcheon or lunule;

beaks much depressed, obtuse, and rising very little above the hinge margin, placed near half-way between the middle and the front; surface with fine lines and small undulations of growth. (Hinge and interior unknown.)

Length, 0.60 inch; height, 0.30 inch; convexity, about 0.19 inch.

Internal casts of this species show an impression near the hinge, behind the beaks, apparently made by a cartilage lamina, such as we see in the genus *Edmondia*, to which I have provisionally referred it. At first I was inclined to think the depressed character of the beaks might be due to some accident; but finding it to be constant in several examples, showing no evidences of distortion, I can but regard it as a natural character of the shell, though this would not *necessarily* prove it to belong to this genus.

In all the specimens yet obtained the anterior margin above the middle seems to be slightly reflexed, as if the valves had been a little gaping there.

Locality and position.—Division C, and Morton's shaft, Nebraska City

EDMONDIA? GLABRA, Meek.

Pl. X, Fig. 7 *a*, *b*.

Shell subelliptical, rather compressed, or moderately convex; length about once and a half the height; extremities rounded, the posterior a little wider than the other; basal margin semielliptic in outline; umbones rather obtuse, rising moderately above the dorsal margin, and placed less than half-way forward from the middle toward the front; cardinal margins sloping very slightly from the beaks backward, and rounding imperceptibly into the posterior margin, declining more abruptly anteriorly, with a slight excavation in front of the beaks, but without a defined lunule; both valves without anterior or posterior umbonal ridge or escutcheon. Surface with faint lines and very obscure traces of stronger concentric marks of growth.

Length, 0.67 inch; height, 0.45 inch; convexity, about 0.20 inch. A single imperfect specimen from the same locality and position, probably of this species, shows obscure rounded concentric undulations, and measures 1.60 inches in length, and about 1.16 inches in height.

All the specimens I have seen being casts of the exterior, giving no clew to the hinge and internal characters, it is only provisionally I have referred this species to *Edmondia*. I know of no species with which it may be confounded, unless it may be some of the forms briefly characterized, by Professor Swallow, under the names *Cypricardia*, *Cardinia*, &c. As near as I can determine from his diagnoses, however, it seems to be distinct from all of these.

Locality and position.—Division C of the Nebraska City section.

EDMONDIA? NEBRASCENSIS, Geinitz, sp.

Pl. X, Fig. 8 *a*, *b*.

Astarte Nebrascensis, Geinitz, 1866, Carb. und Dyas in Neb., p. 16, Tab. 1, Fig. 25.
? *Astarte*, sp., ib., Fig. 27.

Shell subovate, compressed, more or less rounded at the extremities; length nearly once and a half the height; basal margin broadly semielliptic or semiovate in outline; dorsal margin sloping from the beaks, but more abruptly in front than behind, rounding into the extremities; beaks moderately prominent, and located somewhat in advance of the middle. Surface marked by broad, rounded, rather regular concentric

furrows, separated by sharp, moderately prominent concentric linear ridges, which sometimes show under a magnifier indications of being minutely crenate; impressions or furrows between the ridges, showing concentric striæ, which, by the aid of a lens, in a cross light, appear to be crossed by fine, nearly obsolete radiating markings.

Length of largest specimen seen, 1.35 inches; height, 0.95 inch; convexity, about 0.30 inch.

It will be observed that our figure 8 *b* does not exactly agree in outline with that given by Professor Geinitz, and represents a larger shell. Hence I am in some doubt whether or not it is the same. As it came from the same locality and position, however, and agrees more nearly with his figure than any of the other specimens of this size obtained there, I have concluded to refer it provisionally to that species.

From the same bed, at the same locality, a number of smaller, more rounded specimens with more nearly central beaks were obtained, apparently agreeing almost exactly, in their furrows and ridges, with that described above. Fig. 8 *a* of Pl. X represents one of these forms. It was probably from one of these that Professor Geinitz's Fig. 27, of his Tab. 1, was drawn, though that figure represents the beaks more exactly central, and the hinge margin straighter, than any of our specimens. It is possible that these may all belong to the one species, *Nebrascensis;* though I suspect them to be distinct, not merely from the differences of size and form, but because I have not seen satisfactory evidences of their concentric ridges being minutely crenate, as in the larger, more elongated shell. Should these smaller, shorter individuals prove distinct, they may take the name *Edmondia? Geinitzii.*

In regard to the generic relations of these shells, it is proper to remark that Professor Geinitz only referred them provisionally to the genus *Astarte*, and says he thinks they may belong either to *Edmondia* or *Cardiomorpha.* In this opinion I fully concur with him, as it is manifest that they are not true *Astarte*, because they have the dorsal margin behind the beaks, erect, and not inflected or excavated, and want the deeply impressed, sharply defined lunule of *Astarte.* They, moreover, seem to have been much thinner shells than we usually see in that genus. The absence of a defined lunule and inflected dorsal margin also separates these shells from *Astartella*, some of the species of which they closely resemble in form and surface-markings.

These shells seem to be related specifically to some of the forms described by Professor Swallow, under the names *Cardinia*, *Edmondia*, *Cypricardia*, &c., and may possibly be identical with some of them, but so far as I have been able to determine from descriptions alone, they seem to be distinct.

Locality and position.—Division C of the Nebraska City section.

EDMONDIA SUBTRUNCATA, Meek.

Pl. II, Fig. 7.

Shell longitudinally oblong, being between one-third and one-fourth longer than high, moderately convex, the greatest convexity being near the middle; posterior margin subtruncated, though convex in outline and rounding abruptly into the basal and cardinal margins; base but slightly convex in outline along the middle, and rounding up rather more gradually anteriorly than behind; anterior margin short and narrowly rounded below, abruptly and obliquely truncated above; dorsal margin nearly straight and scarcely declining behind the beaks; beaks rather depressed, convex, and placed nearer the anterior end than the middle.

Surface of cast marked with moderately distinct irregular undulations.

Length, 1.33 inches; height, 0.95 inch; convexity, about 0.50 inch.

It is possible that this may be the form figured by Professor Geinitz on Plate I of his work on the Nebraska fossils, as *Astarte gibbosa* of McCoy, though it is proportionally longer, being more oblong in outline, and less ventricose. Neither of these shells belong to the genus *Astarte*, however; they are probably *Edmondia* or *Cardiomorpha*. The identity of either of them with McCoy's species is exceedingly doubtful, however.

Locality and position.—Rock Bluff, Nebraska, Upper Coal-Measures; we also have it from a still lower position in the Coal-Measures at Atchison, Kansas, and, I believe I have seen it in the Illinois Lower Coal-Measures, though of this I am not quite sure.

EDMONDIA ASPINWALLENSIS, Meek.

Pl. IV, Fig. 2 *a*, *b*, *c*.

Edmondia Aspinwallensis, Meek, 1871, Dr. Hayden's Report of Geol. Survey Wyoming, p. 299.

Shell longitudinally subovate, moderately convex, the greatest convexity being a little in advance of and above the middle; base nearly semielliptic in outline; posterior side rather narrowly rounded, or sometimes very faintly subtruncate obliquely above; dorsal margin nearly straight just behind the beaks, but very gradually declining with a slightly convex outline posteriorly; anterior side quite short and declining very abruptly from the beaks above, and rounded below; beaks rather depressed, incurved, and located nearer the anterior end than the middle. Surface of cast with moderately distinct, irregular concentric undulations; showing behind the beaks distinct impressions of the cartilage fulcra.

Length, 1.45 inches; height, 1.03 inches; convexity, about 0.68 inch.

This species resembles the last somewhat, but differs in being more ovate, instead of nearly oblong, owing to its narrower posterior extremity, and more elevated beaks. Its undulations are also more obscure, and its beaks more pointed.

Locality and position.—Aspinwall on the Missouri, in apparently a somewhat higher horizon than any of the beds exposed at Nebraska City. It also occurs at various horizons in the Coal-Measures of Illinois, and in the Lower Coal-Measures of West Virginia.

Genus CHÆNOMYA, M. & H.

CHÆNOMYA LEAVENWORTHENSIS, M. & H.

Pl. II, Fig. 9.

Allorisma Leavenworthensis, Meek & Hayden, Dec'r, 1858, Proceed. Acad. Nat. Sci. Philad., p. 263.

Chænomya Leavenworthensis, Meek, 1864, Palæont. Upper Missouri, Part 1, p. 43, Pl. II, Fig. 1, *a*, *b*, *c*.

Of this curious shell, we have but a single fragment, consisting of the posterior, extremely widely gaping portion of the two valves united. The species is so peculiar, however, and so entirely unlike any other form known in these rocks, that it can scarcely be possible to confound it with any other shell. It shows the lines of growth, and small concentric wrinkles, abruptly deflected parallel to the distinctly truncated

and widely gaping posterior margin, very clearly; and even the radiating rows of minute granules are well preserved on the lower half.

Locality and position.—The specimen figured is from near the middle of the Rock Bluff section of the Upper Coal-Measures. The species was originally described, from a dark argillaceous limestone of the Coal-Measures, at nearly the level of the Missouri River, at Leavenworth, Kansas. It also occurs in the Coal-Measures of Iowa, Missouri, and Illinois, being sometimes found below the middle of the series in the latter State.

CHÆNOMYA MINEHAHA, Swallow, sp.

Pl. —, Fig. 13 *a b*.

Allorisma ? Minehaha, Swallow, 1858, Trans. St. Louis. Acad. Sci., Vol. I, p. 193.
Chænomya Minehaha, Meek & Hayden, 1858, Palæont. Upp. Mo., p. 43.

Shell rhomboidal in outline, very convex, distinctly less than twice as long as high; posterior truncation very oblique, and gaping nearly to the full breadth of the united valves, but without reflexed edges, dorsal margins comparatively short, concave in outline, and rather distinctly inflected; basal margin forming a gentle curve from the sub-angular posterior basal extremity forward, and obliquely ascending anteriorly to the very short abruptly rounded anterior end; beaks very oblique, depressed, incurved, and located nearly over the anterior extremity; posterior umbonal slopes prominently rounded or sub-angular, and extending obliquely backward and downward to the posterior basal angle. Surface of cast showing obscure marks of growth parallel to the basal and truncated posterior margin, being rather abruptly flexed in crossing the umbonal ridge.

Length, 1.58 inches; height at posterior end of hinge, 0.92 inch; convexity near the middle, 0.78 inch; breadth of posterior gap, 0.56 inch.

I am not entirely sure that this is Professor Swallow's species, though it agrees pretty well with his description, and almost exactly with a tracing in my possession of one of Professor Swallow's drawings, understood by me to be from his type specimen. It will be distinguished from the last by its shorter and more rhombic form, more obliquely truncated posterior margin, and shorter, narrower, and more oblique anterior. Perfect specimens would probably show the usual granulations of the surface.

Locality and position.—The typical specimens described by Professor Swallow, were from the Middle Coal-Measure, at Lexington, Missouri. That here described and figured on Pl. II, was found in the Coal-Measures, at Plattsmouth, Nebraska, in bed No. 2, of the section at that place; but it was inadvertently omitted, among the fossils mentioned in the Plattsmouth section.

Genus ALLORISMA, King.

ALLORISMA (SEDGWICKIA) REFLEXA, Meek.

Pl. X, Fig. 15.

Shell rather small, longitudinally subovate, rather convex in the central region; nearly twice as long as high; anterior margin rounded in outline; base forming a subelliptic curve, excepting that it is slightly sinuous in advance of the middle; posterior margin compressed, and ascending obliquely *from the base* nearly half-way up, and a little

straightened, or even slightly sinuous, in outline; above the middle, truncated obliquely forward and distinctly gaping or reflexed; dorsal margin concave in outline behind the beaks, and rounding forward into the anterior border in front of them; beaks depressed and placed near halfway between the middle and the front, with slight backward inclination, somewhat as in *Nuculana;* posterior dorsal part of the valves compressed, and provided with two obscure ridges nearly parallel with the cardinal edge, excepting that the lower, which is usually wider than the other, is more oblique. Surface ornamented with obscure lines of growth, and small, very regular concentric wrinkles, which become obsolete on the posterior dorsal portion of the valves, and quite distinct on all the more convex parts, where they curve parallel to the basal outline, being a little straightened, or even very slightly arched, as they cross an obscure, undefined concavity extending from near the beaks to the sinuous part of the base; crossing the concentric marking, exceedingly small, or almost microscopic, rather distant radiating lines may also be seen under a strong magnifier; on the anterior part of the valves, and near the beaks, these lines seem to be nearly or quite continuous, but on the posterior ventral portions they are seen to be composed of the usual minute granules.

Length, 1.50 inches; height about 0.55 inch; convexity near 0.38 inch.

This must be a very neat, pretty species, when found entire. It is remarkable for its concave dorsal margin behind the beaks and its abruptly gaping truncated posterior extremity. This gap, however, is entirely above the middle, and seems to have a somewhat upward direction. In its gaping posterior, and some of its other characters, it resembles the genus *Chænomya*, though its general physiognomy is different, being much more like that of *Lyonsia.* Specifically, it is perhaps most nearly related to the shells described by Dr. Shumard from the Upper Coal-Measures of Kansas, under the names *Leptodomus Topekaensis* and *L. granosus* (Trans. St. Louis Acad. Sci., 1, pp. 207 and 208), though as near as I can determine from descriptions alone, it must be clearly distinct from both, on account of its concave dorsal outline, want of posterior umbonal ridge, and in its gaping posterior extremity, &c.

It is quite probable that it was to this species that Professor Geinitz alludes, in connection with that I have described under the name *A. Geinitzii* (which he referred to *A. elegans*), as being an intermediate connecting link between the *A. Geinitzii* and *A. elegans.* He was probably led into this view by not having a sufficiently extensive series of the *A. Geinitzii* for study; otherwise he would certainly have seen that the little shell never attained more than one-fourth the size of this, and not only differs in general outline, and the absence of any traces of the distinct regular concentric wrinkles of this species, but in the constant possession of a sharply defined posterior umbonal carina, of which there is no trace in this shell. I probably must have seen altogether, at the localities and in the material collected, not less than one hundred specimens of *A. Geinitzii*, not one of which was even half as large as this, while they all possess the sharp carina, and show no tendency whatever to vary into the form or *A. elegans.* In short, it is remarkably constant in all of its characters, and perhaps the most strongly defined species in all of our rocks.

Locality and position.—Division C of the Nebraska City section. It also occurs in both the upper and lower divisions of the Coal-Measures of Illinois.

ALLORISMA (SEDGWICKIA) GEINITZII, Meek.

Pl. X, Fig. 16 *a*, *b*.

Allorisma elegans, Geinitz, 1866, Carb. und Dyas in Neb., p. 13, Tab. 1, Fig. 21; (not of King, 1844).
——*Geinitzii*, Meek, 1867, Am. Jour, Sci. and Arts, Vol. XLIV, new series, p. 170.

Shell small, rather compressed, longitudinally subovate, abruptly narrowed from the beaks posteriorly; umbonal slopes distinctly carinate from the beaks to the posterior basal angle; anterior side subtruncate, with an abrupt slope from the beaks obliquely forward above, and rounding into the base below; basal margin somewhat prominently rounded anteriorly, and nearly straight or faintly sinuous behind; posterior end compressed, its margin abruptly truncated vertically, so as to make its upper and lower parts nearly rectangular; cardinal margin sloping with a slightly concave outline, from the beaks to the truncated posterior end; beaks elevated, incurved, and placed about half-way between the middle and the anterior extremity of the valves. Surface ornamented with numerous, minute, closely crowded granules, which, on the umbones and other parts of the valves in front of the angular umbonal slope, show a tendency to arrange themselves in radiating lines, which are crossed by more or less distinct lines of growth; on the compressed corselet above and behind the umbonal carina, there are usually two or more obscure radiating ridges and furrows, crossed by moderately distinct, granular lines of growth, parallel to the truncated posterior margin.

Length of the largest example seen in a fine series of specimens, 0.50 inch; height of umbones in ditto, 0.30 inch; height of truncated posterior end same, 0.16 inch; convexity, about 0.13 inch.

This beautiful little shell was referred by Professor Geinitz to *Allorisma elegans* of King, but I have no doubt whatever in regard to its being a clearly distinct species, our figure 16 *a* of Pl. X, being the largest specimen of a series of about sixty examples; while *A. elegans* attains the size of figure 22 *b* of the same plate, copied for comparison from Professor King's typical figure. It is also easy to see from this and Fig. 22 *a* of same plate, copied from another figure of *A. elegans*, given by Professor Geinitz in his Dyas (Tab. XII, Fig. 14*b*) of a German specimen, that the form of our Nebraska shell is entirely different, so much so, indeed, as to suggest doubts whether it really belong to the same genus. In the first place it will be observed that our shell has its umbones and anterior ventral region much more prominent, and its posterior half more narrowed and abruptly truncated. Its umbonal ridge is likewise always *distinctly carinate.*

Professor Geinitz noticed some of these differences, but thought them not of specific importance, because *A. elegans* is variable, particularly in the umbonal angle, and he had seen a much larger specimen from Nebraska, with the umbonal ridge blunt. I can only say, however, that a series of about sixty specimens before me shows the Nebraska shell under consideration to be exceedingly constant in all its characters; while none of these specimens I have seen exceed in size that represented by Fig. 16 *a* of Plate X. The last-described species, however, from the same locality and position, is a larger somewhat similar shell, belonging to an entirely different species, with a rounded umbonal slope. This I suspect, as already suggested, is the one alluded to by Professor Geinitz.

Locality and position.—Very common in division C at Nebraska City, to which horizon I at one time supposed it to be confined. More recently, however, I have seen specimens of this shell, presenting *exactly* the same characters, from the Upper, *Middle, and* Lower Coal-Measures of Illinois.

ALLORISMA (SEDGWICKIA?) SUBELEGANS, Meek.

Pl. X, Fig. 14.

Shell small, rather compressed, less than twice as long as high, greatest convexity near the middle, and in advance of it; both extremities closed; anterior margin rounded into the base from near the middle, nearly straight and sloping forward from the beaks above; posterior extremity obliquely subtruncated, but connecting with the base and cardinal margin, without any defined angle; cardinal margin inflected, nearly straight, and sloping slightly from the beaks; base rather straight and subparallel to the hinge along the middle, but rounding up at the extremities; beaks rather broad, moderately prominent, and placed a little in advance of the middle; umbonal region somewhat compressed along the middle; posterior umbonal slopes moderately prominent, in consequence of the compression of the posterior dorsal region, but not carinated, nor even forming a defined ridge. Surface ornamented with concentric striæ, and small undulations of growth, which are distinctly and regularly defined on the umbones and more convex portions of the valves, but become abruptly obsolete on the compressed postero-dorsal region; extremely minute granules also cover the entire surface in very closely-crowded radiating rows.

Length, 0.56 inch; height, 0.32 inch; convexity about 0.20 inch.

This little shell is evidently allied to *A. elegans* of King, indeed, much more so than the last, which has been identified by Professor Geinitz with that species. After a critical comparison, however, with Professor King's figure and description of *A. elegans*, as well as with those of German examples of the same published by Professor Geinitz, I do not feel warranted in identifying the form under consideration with that species. At any rate, it differs in having its umbones wider, and placed farther back, as well as more compressed, while its concentric undulations are more strongly and regularly defined on its umbonal and central regions. In fact, it seems to me to be as much like young examples of a Carboniferous shell figured by Professor McCoy, in his British Palæozoic Fossils, Pl. 3 F, under the name *Leptodomus variabilis*, particularly his Figure 8, of the plate cited.

That this shell is clearly distinct from the last is too obvious to require a careful comparison, especially when it is remembered that we have not less than fifty or sixty specimens of that shell, all agreeing with remarkable exactness with the figures given; while of the form here under consideration but the single example figured was found among all the collections yet obtained. It may be well to remark, further, that in addition to the manifest differences of form, the species under consideration has its surface granules much more minute, being, in fact, almost invisible, except when looked for in a good light, with a *strong* magnifier; while in the last they are visible, on well-preserved specimens, to good eyes without the aid of a magnifier of any kind.

Locality and position.—Same as last. It also occurs at various horizons in the Coal-Measures of Illinois.

ALLORISMA (SEDGWICKIA) GRANOSA, Shumard, sp.

Pl. II, Fig. 8.

Leptodomus granosus, Shumard, 1858, Transactions St. Louis Acad. Sci., Vol. 1, p. 207. Compare *L. Topekaensis*, Shumard, 1858, ib., p. 208.

Shell very thin, approaching an irregular, oblong form, the length being less than twice the height, very convex, the most gibbous part

being near the middle of the valves; beaks prominent, incurved, somewhat flattened on the outer side, and placed about half way between the middle and the front. Dorsal margin straight behind the beaks, and nearly parallel to the general outline of the base, inflected so as to form a distinct, flattened, lanceolate, lunule-like area, bounded on each side by a well-defined, subangular ridge; posterior side nearly or quite closed, obliquely truncated, with sometimes a faint sinuosity near the middle; anterior side rather abruptly sloping forward, and straightened above, and rounding into the base below, near which it seems to be a little gaping; base somewhat straightened, or even a little sinuous in outline, just in front of the middle, at the termination of a broad, very shallow concavity, extending a little obliquely downward and backward from the umbonal region; behind this rather prominent, thence ascending obliquely with a slightly convex outline, to the truncated posterior margin. Posterior umbonal slopes very prominently rounded above, and continued as a low undefined ridge, obliquely backward and downward; posterior dorsal slope, above the umbonal ridge, with an oblique, shallow, rounded sulcus, extending from the back part of the beaks to the middle of the truncated margin behind. Surface marked with fine lines of growth and small irregular concentric wrinkles, which latter are not defined on the posterior dorsal region above the umbonal ridge; crossing these are the usual radiating rows of minute granules.

Length, 2 inches; height, 1.15 inches; convexity, 1 inch.

Dr. Shumard described two species, *L. granosus* and *L. Topekaensis*, and without figures to illustrate the differences, I am left in some doubt which of his species this is, though it agrees best with the first. Both of these species belong to the same group as *Allorisima concava*, M. & H; *A. Geinitzii*, Meek; *Sanguinolites variabilis*, and *S. costellatus*, McCoy, and probably *A. elegans*, King. They differ from the typical forms of the genus *Allorisma*, in presenting a peculiar Lyonsia-like physiogomy, and should probably form at least a distinct section of the genus, if not an entirely different genus. McCoy referred his species to *Leptodomus*, but I cannot think them congeneric with the type upon which he *first* proposed to found that group. To me they appear more nearly allied to the original typical form of his *Sedgwickia*, which latter name I am inclined to retain for them, at least in a subgeneric sense.

Locality and position.—The specimen figured on Plate II was obtained at Rock Bluff, on the Missouri, in the Upper Coal-Measures. Dr. Shumard's typical specimen was found in the same horizon, on Verdigris River, Kansas.

ALLORISMA SUBCUNEATA, M. & H.

Pl. II, Fig. 10 *a*, *b*.

Allorisma subcuneata, Meek & Hayden, Decr. 1858, Proceed. Acad. Nat. Sci. Philad., p. 263; Palæont. Upp. Mo., 1864, Part 1, p. 37, Pl. 1, Fig. 10 *a*, *b*; Geinitz, 1866, Carb. und Dyas, p. 76.

? —— *ensiformis*, Swallow, 1860, Trans. St. Louis Acad. Sci., Vol. 11, p. 653.

Shell attaining a large size, longitudinally elongated, or twice to three times as long as high, the proportional length increasing with age, greatest convexity a little in advance of the middle and in the umbonal region; cuneate and a little gaping behind, where the margin is more or less narrowly rounded in outline. Basal and dorsal margins nearly parallel, the latter being more or less concave in outline, or nearly straight, and inflected so as to form a lanceolate kind of false area, bounded by an obtuse ridge on *each side, just outside* of which there is a shallow unde-

fined sulcus; basal margin slightly convex, or somewhat straightened along the middle, and sometimes very faintly sinuous just under the beaks, rounding up more abruptly before than behind; anterior margin very short, a little gaping and rather prominently rounded below; beaks convex, incurved, and placed near the anterior end, rather depressed, but rising moderately above the dorsal margin. Surface ornamented with fine striæ of growth, and well-defined concentric undulations usually most distinct and regular on the beaks and umbonal region.

Length of largest specimen seen, 4.81 inches; height from ventral to dorsal margin, near middle, 1.76 inches; convexity, 1.57 inch.

This fine species has neither umbonal ridge nor lunule, properly speaking, though there is an undefined excavation in front of the beaks, and an obscure ridge extending from the back part of each beak to the posterior extremity of the hinge. Like perhaps all other species of this and several allied genera, this species, when well preserved, has its entire surface covered with granules. These granules are rather scattering and, as usual, arranged in radiating rows; it is very rarely, however, that specimens are found in a condition to show these delicate surface characters, since there are usually no traces of them on casts of the shell.

The typical specimens upon which this species was founded were rather imperfect, and the one figured in the Palæontology of the Upper Missouri (Pl. 1, Fig. 10) has the posterior extremity broken away. The blank restoration of this wanting portion has the outline represented somewhat inaccurately, so as to give an unnatural straightness to the hinge. I have also since ascertained that the sinus of the pallial line which is exceedingly obscure and very rarely seen, is there represented rather too angular in outline.

In many respects this species very closely resembles *A. regularis*, King as figured on Pl. XIX, Fig. 6, of the Geol. Russia, Vol. II. Indeed, the resemblance is so close that at one time I was inclined to think they might possibly be the same. On comparison of the dorsal view, however, as represented by our Figure 10*a*, Pl. II, it will be seen that the inflected portion of its cardinal margin is much broader than in the Russian species, so as to form a broad lanceolate excavation, instead of a mere linear depression. In addition to this, our shell has a ridge along the hinge, on each side of the depression alluded to, not seen in the Russian shell.

Although Professor Swallow's diagnosis of his *A. ensiformis* does not agree in all respects with the shell under consideration, I am inclined to think this and the obscurity of his description has arisen from the accidental omission by the printer of a part of the description. At any rate, I have not much doubt, from a tracing of his typical specimen before me, that his shell and that under consideration are identical. It is rather longer in proportion to its height, and has its anterior extremity a little shorter than the specimen here figured, but a good series of specimens shows the species to vary in these respects.

Locality and position.—Rock Bluff, where it is quite abundant in bed No. 9 (see section of that place); two and one-half miles southwest of Nebraska City; Wyoming, &c., in beds referred by Professor Geinitz and Professor Marcou to the Dyas; also at Leavenworth and Atchison, Kansas; Plattsmouth, Nebraska, and in short at numerous places in the Coal-Measures of the Western States. It is not uncommon in both the Upper and Lower Coal-Measures of Illinois.

Genus PROTHYRIS, Meek.

PROTHYRIS ELEGANS, Meek.

Pl. X, Fig. 9 *a*, *b*.

Prothyris, Meek, 1869, Proceed. Acad. Nat. Sci. Phila., July, p. 172.
—— *elegans*, Meek, 1871, American Jour., Conchology, Vol. VII, p. 5, Pl. 1, Fig. 3.

Shell compressed, elongate-oblong, the length being about three and a half times the height; ventral and dorsal margins straight or a little arched; the latter with a faintly defined marginal furrow, below which there is usually an obscure ridge also parallel to the dorsal margin; posterior extremity obliquely subtruncate, the most prominent part being below the middle; beaks compressed, depressed, not distinct from the dorsal margin, and placed about one-eighth or one-ninth the length of the valves behind the anterior extremity; notch of the anterior margin well defined, and extending about half way up from the base, and near half the distance back from the front to the beaks; ridge from the inner angle of the notch narrow, flat, and widening slightly from above; anterior margin above the notch rounded, and having the appearance of a little flattened ear; surface striæ nearly obsolete on the upper half of the valves, and more distinct on the ventral and antero-ventral regions.

Length of largest specimen seen, 1.07 inches; height, 0.33 inch; convexity, about 0.08 inch.

The only other species of this genus known to me is from the lowest member of the Carboniferous system in Michigan and Ohio, known in the former State as the Marshall group, and in the latter as the Waverly group. This older species (*P. Meeki* of Winchell) is more convex, with the anterior ventral angle less sharply defined, and the posterior margin more sloping above.

Locality and position.—Nebraska City, division C. It also occurs at different horizons in the Coal-Measures of Illinois.

Genus SOLENOPSIS, McCoy.

SOLENOPSIS SOLENOIDES, Geinitz, sp.

Pl. X, Fig. 3.

Clidophorus solenoides, Geinitz, 1866, Carb. und Dyas in Neb., p. 25, Tab. II, Fig. 7.

Shell small, rather compressed, elongated, the length being about four times the height, narrowing posteriorly; cardinal margin nearly straight, erect, less than the entire length of the valves, with a faint external compression or shallow furrow just below it; basal margin broadly convex in outline, the most prominent part being in advance of the middle; posterior extremity very narrow, and faintly subtruncate; beaks much depressed and compressed, or scarcely distinct from the cardinal margin, placed within about one-eighth the entire length of the shell from the anterior extremity, and defined in front by a short vertical indentation; anterior side narrowly rounded, or with the upper side sometimes faintly truncated, with slight slope from the little indentation forward; surface with very fine, regular striæ of growth, which are nearly or quite obsolete, excepting on the lower half of the valves.

Length of one of the largest specimens, 0.60 inch; height, 0.15 inch; convexity, about 0.06 inch.

I have not seen the hinge of this shell, but, from its external characters, I can scarcely doubt that it really belongs to the genus *Solenopsis*. All the specimens I have examined, show an indentation just in advance of

the beaks, somewhat like that left on internal casts of *Pleurophorus* by the internal ridge; but so far as I have been able to see, there would seem to be no impressions of long posterior lateral teeth like those of that genus, left in the matrix. Casts of the *exterior*, showing the finest lines of growth quite distinctly, indicate that the little indentation alluded to in front of the beaks must be impressed on the outside of the shell, though it doubtless also corresponds to an internal ridge.

Compared with *S. minor*, Professor McCoy, the type of the genus *Solenopsis*, the form here under consideration, seems only to differ specifically in being more attenuated and less distinctly truncated posteriorly. Among American species, it is most nearly related to *Solen scalpriformis* of Winchell, from the oldest division of the Carboniferous system in this country. Professor Winchell's species is larger, however, and agrees more nearly in form with Professor McCoy's type. I think these shells are all congeneric.

Locality and position.—Division C of the Nebraska City section. I have not seen it from any other locality or position in Nebraska, but it occurs in a lower position in the Coal-Measures of Illinois.

GASTEROPODA, Cuvier.

Genus DENTALIUM, Linnæus.

DENTALIUM MEEKIANUM, Geinitz.

Pl. XI, Fig. 16 *a*, *b*.

Dentalium Meekianum, Geinitz, 1866, Carb. und Dyas in Neb., p. 13, Tab. 1, Fig. 20.
Compare *D. ingens*, de Kon., 1844, An. Foss., p. 317, Pl. XXII, Fig. 2.

I have preferred to copy Professor Geinitz's figure of this species to figuring the only Nebraska specimen I have seen of it, because the latter is distorted and does not show the surface markings. From Professor Geinitz's figure, and the specimen alluded to, it is evident that the shell varied from 0.60 to 0.75 inch in length; is moderately curved, and increases rather rapidly in size from the smaller to the larger end, the aperture being nearly or quite circular. His figure shows that it has no longitudinal striæ, and its lines of growth to be fine, moderately distinct, and passing very obliquely around, with at regular intervals, a deeper sulcus. These lines, and occasional deeper grooves, are represented in his figure, apparently as if they passed spirally around; this, however, is certainly incorrect.

This species is evidently closely allied to *D. ingens*, de Kon., from the Carboniferous rocks of Belgium, from which it seems to differ only in its smaller size.

Locality and position.—Nebraska City bed C, of the section at that place. It also occurs near the middle of the Coal-Measures of Illinois.

Genus BELLEROPHON, Monfort.

BELLEROPHON CARBONARIUS, Cox.

Pl. IV, Fig. 16; Pl. XI, 11, *a*, *b*, *c*.

Bellerophon Urii, Norwood and Pratten, 1865, Jour. Acad. Nat. Sci. Philad., Vol. III, second series, p. 75, Pl. IX, Fig. 6 *a*, *b*, *c*; (not Fleming, 1828).
——— *carbonarius*, Cox, 1857, Kentucky Geol. Report, Vol. III, p. 562; Dana's Man. Geol., p. 349, Fig. 598.
——— *Blaneyanus*, McChesney, 1860, New Palæozoic Fossils, p. 60; and 1865, Pl. 2, Fig. 5, illustrations of same.
——— *carbonarius*, Geinitz, 1866, Carb. und Dyas in Nebraska, p. 6, Tab. 1, Fig. 8.

Shell globose, broadly rounded over the dorsum; umbilical impressions very small or closed. Aperture transversely sublunate, much

wider than high, and strongly arched, but not expanding more rapidly than the uniform increase in the size of the volutions; inner lip nearly wanting or little developed; outer lip moderately thick near the umbilicus on each side, but thinner between; sinus shallow and rounded, its band obscure or scarcely visible on the costated part of the outer whorl, sometimes a little concave, or with, on each side, traces of a faintly marked ridge on the smooth part of the outer volution; surface, excepting on the terminal half or third of the body whorl, ornamented with about eighteen to twenty-five simple, rather distinct, revolving raised lines or costæ, some two or three of which are usually a little smaller and closer together on the mesial band than the others, while a few of these near the umbilicus on each side, just at the commencement of the smooth part of the outer whorl, are broken up into little elongated, oblique, node-like prominences; lines of growth obsolete.

Transverse and longitudinal diameters (of a medium-sized specimen), each 0.56 inch.

This shell is very nearly related to *B. Urii* of Fleming, and if it is possible that some slight details in the ornamentation of that species have been overlooked by those who have figured and described it, our shell may possibly not be distinct. As remarked by Professor Cox and Professor McChesney, the *B. carbonarius* differs from the published figures and descriptions of *B. Urii* in having about thirteen to eighteen costæ less, and in having a few of those on each side of the outer whorl, as stated above, near the umbilicus, broken up into little oblique, elongated ridges or interupted lines.

Locality and position.—This species is widely distributed and has a considerable vertical range in the Coal-Measures of the West. The specimen here figured on Pl. XI, was collected from division C of the section at Nebraska City, included by Professors Marcon and Geinitz in their Upper Dyas. We also have it from Mr. Morton's shaft, near Nebraska City, and from division B at that place, as well as from two miles and three-fourths west of Nebraska City, and numerous other places in Nebraska, at different horizons in the Coal-Measures. In Iowa, Kansas, Missouri, Illinois, Kentucky, and portions of Southwestern Indiana, it is a common Coal-Measure species. I have also identified it from the Lower Coal-Measures of West Virginia, among collections sent by Professor J. J. Stevenson, of Morgantown.

BELLEROPHON MONTFORTIANUS, N. & P.

Pl. XI, Fig. 15; and 12?

Bellerophon Montfortianus, Norwood & Pratten, 1855, Jour. Acad. Nat. Sci., Philad., Vol. III, sec. ser., p. 74, Pl. IX, Fig. 5 *a*, *b*, *c*.; Geinitz, 1866, Carb. und Dyas in Neb., p. 8, Tab. 1, Fig. 13.

Shell with inner volutions comparatively small; outer one greatly expanded at the aperture, both in length and breadth; umbilicus very small or closed; aperture large and transversely reniform; sinus of lip narrow and moderately deep, its band narrow, well defined, and a little raised in the middle of a rather deep, wide sulcus; outer lip thin and rounded in outline on each side of the sinus, but more or less thickened near the umbilicus; inner lip callous, particularly in the middle, where it often swells out in the form of a large prominent node in old specimens; surface beautifully ornamented with two sets of raised longitudinal lines, the larger being usually with several of the smaller between; crossing all of these, there are numerous, much more regular, crowded, very fine striæ, which curve gracefully as they cross the dorsal band;

on the expanded portion of the outer volution, the larger longitudin lines increase in size, and become more spread out; that portion of th body volution not expanded, and the inner whorls are also ornament by large, somewhat interrupted transverse ridges, extending from ne the dorsal band to the umbilical region on each side; the finer markin already mentioned being defined on these ridges as on other parts of t surface.

Our specimens are too much broken and distorted to afford accur measurements. One, however, shows that the aperture was not l than 1.13 inches in breadth, while the body whorl, just at the co mencement of the expansion, is not more than 0.45 inch across in t same direction.

This beautiful species is remarkable for the great expansion of aperture in proportion to the size of the inner whorls composing t body of the shell. It is very rarely the case that specimens are fou with the expanded part of the outer volution entire, and it was dou less from this reason that my friends Norwood and Pratten suppos the lip to be probably without the usual dorsal sinus, not having se any specimens with the lip entire.

The figure I have given was drawn from an artificial cast made i mould left in the fine clay matrix, so sharply defined as to show the m minute surface-markings. I also have before me several natural ca of the body part of the shell, more or less distorted, such as that figu by Professor Geinitz. From all of these specimens I am inclined suspect that the enlarged figure, 14, given by Professor Geinitz plate, 1, of his Carb. und Dyas (Fig. 12 of our Pl. XI), of the expand part of a shell he refers to *Bellerophon interlineatus*, Portlock, may long to the species under consideration. It certainly agrees well w the expanded portion of *B. Montfortianus* in surface-markings, t part of this species being entirely destitute of the large transve ridges seen on other parts of the shell; while the longitudinal lines costæ spread out there and always show from two to three or four fi lines between each two of the larger, which are here increased in s His specimen evidently has the margin of the lip broken away so as to show the sinus.

Locality and position.—The specimen figured, and some seven or ei other imperfect examples, were obtained from bed C of the Nebra City section, at that place. It also occurs there in bed B, and at merous other places in Nebraska, Kansas, Iowa, Missouri, Illinois, at various positions in the Coal-Measures. Professor Stevenson found it associated with the last in the Lower Coal-Measures of W Virginia.

BELLEROPHON MARCOUIANUS, Geinitz.

Pl. IV, Fig. 17; and pl. XI, Fig. 13 *a*, *b*.

Bellerophon Marcouianus, Geinitz, 1866, Carb. und Dyas in Neb., p. 7, Tab. 1, Fig. 1

The specimens of this species yet known, either in the collections under investigation or among those obtained by Professor Mar are too imperfect to give a correct idea of its characters. It is eviden however, one of those rapidly expanding species, with a very small b and a greatly dilated mouth, like *B. Montfortianus* and *B. percarina* Conrad. Yet it differs from these distinctly, in having no transv ridges or nodes, and in being marked with exceedingly fine, regu longitudinal striæ. It also shows very minute lines of growth, which crossing the band, bend backward so as to indicate a rather shal

sinus. The band forms a moderately prominent ridge, which, however, is not so abruptly raised, nor so roughened by the crossing of the marks of growth, in the specimens I have seen, as in that figured by Professor Geinitz. The longitudinal lines are extremely minute, and closely crowded on the band; and the umbilicus seems to be open.

Specimens with the lip entire may have attained a diameter of one inch.

Locality and position.—Nebraska City, division C, of the section seen at that place; likewise from Morton's shaft one mile and three-fourths west of there. Internal casts of a form probably identical with this also occur in the Upper Coal-Measures of Union County, Iowa, and at the same horizon in Kansas. It likewise occurs in the Coal-Measures of Illinois; and I think I have seen imperfect specimens of it among Professor Stevens's collections from the Lower Coal-Measures of West Virginia.

BELLEROPHON PERCARINATUS, Conrad.

Pl. XI, Fig. 14.

Bellerophon percarinatus, Conrad, 1842, Jour. Acad. Nat. Sci., Philad., Vol. VIII, Pl. 16, Fig. 5; Norwood & Pratten, 1854, Jour. Acad. Nat. Sci., Philad., Vol. III, new series, p. 74, Pl. IX, Fig. 4.

Of this species we have but a single distorted fragment, though it is quite sufficient to show its identity with the shell from the Illinois Coal-Measure, and the same horizon at other western localities, usually referred to Mr. Conrad's *B. percarinatus*. Mr. Conrad's species was originally described from Western Pennsylvania, where it was found associated with *Pleurotomaria sphærulata* and *P. tabulata*, Conrad, which are also common in Illinois, Missouri, Iowa, &c. Mr. Conrad's type specimen was probably distorted by lateral pressure, so as to make its mesial ridge more prominent than is natural in the western specimens. At any rate, I cannot think this a specific difference, since specimens from West Virginia agree well in this character with those found farther westward.

As known in the West, the shell under consideration is of medium, or rather above medium size, expands very rapidly at the aperture, which seems to have been much like that of *B. Montfortianus*, N. & P. Its umbilicus is closed by the rapid expansion of the body whorl; while its dorsal side, which is somewhat rounded, has three longitudinal nodose ridges, the middle one of which is the most prominent, the nodes being at the points where a series of transverse costæ, or ridges, cross over the dorsum from one umbilicus to the other. It seems to be otherwise only marked by small lines of growth.

Locality and position.—The specimen figured on Pl. XI, Fig. 14, is from division C of the Nebraska City section. We also have it from Brownville on the Missouri. The specimen figured by Norwood & Pratten is from the Upper Coal-Measures at Grayville, Illinois. It occurs at other localities in the same position in Illinois, Iowa, Missouri, &c.; also in the Lower Coal-Measures of West Virginia.

Genus PLATYCERAS, Conrad.

PLATYCERAS NEBRASCENSIS, Meek.

Pl. IV, Fig. 15 *a*, *b*.

Shell rather small, very obliquely elongate-conical, and strongly curved; apex free, oblique, somewhat obtusely pointed, curved and twisted to the right (*looking at the shell* with the apex behind); aper-

ture subcircular or oval; lip thin and sharp, broadly sinuous nearly under the apex on the concave side, and sometimes provided with five or six smaller sinuses around the remaining sides; surface with more or less distinct marks of growth, usually strongly undulated parallel to the sinuses, and inequalities of the lip.

Length, 0.88 inch; breadth, 0.56 inch.

This species resembles more or less nearly several of those described from different horizons in the Western States, but after a critical comparison I have been unable to identify it with any of them.

Locality and position.—From a shaft one mile and three-fourths west of the Nebraska City landing. It also occurs near the middle of the Illinois Coal-Measures.

Genus MACROCHEILUS, Phillips.

MACROCHEILUS INTERCALARIS, *var.* PULCHELLUS, M. & W.

Pl. VI, Fig. 8.

Macrocheilus intercalaris, Meek & Worthen, 1860, Proceed. Acad. Nat. Sci. Philad., p. 467; 1866, Geol. Rep. Ill., Vol. II, p. 371, Pl. 31, Fig. 6 *a b*.
——— *pulchellus*, M. & H., 1860, ib.

This shell agrees closely with certain forms of *M. intercalaris*, M. & W., from the Upper Coal-Measures of Illinois, particularly with the form we at one time proposed to call *M. pulchellus*, which differs mainly from the typical *intercalaris* in having its spire a little more elevated, and its whorls slightly more convex. This, however, I do not now regard as a specific difference.

Locality and position.—Two miles and three-fourths southwest of Nebraska City. An imperfect cast of apparently a larger individual of the same species was also found at near the same horizon one mile and three-fourths west of Nebraska City, at Hon. J. S. Morton's place. The original typical specimens were found in the Upper Coal-Measures at Springfield, Illinois. I have also seen the same shell in a small collection belonging to Dr. R. P. Stevens, from near Pittsburg, Pennsylvania. I believe I have also seen it among the Lower Coal-Measure fossils from West Virginia.

Genus ORTHONEMA, M. & W.

ORTHONEMA SUBTÆNIATA, Geinitz, sp.

Pl. XI, Fig. 10.

Murchisonia subtæniata, Geinitz, 1866, Carb. und Dyas in Nebraska, p. 12, Tab. 1, Fig. 16
Orthonema subtæniata, Meek, 1867, Am. Jour. Sci. & Arts, Vol. XLIV, second series, p. 178.

Although I have had an opportunity, through the politeness of Dr. White, to examine a fine specimen of this neat little shell, from the same horizon in Western Iowa, I have yet only seen imperfect fragments of it from Nebraska City; consequently I have preferred to give a copy of Professor Geinitz's figure, which appears to be an accurate representation of a perfect specimen. From this it may be seen to be a very small, elongate-conical, rather symmetrical shell, composed of eight or nine compactly wound, moderately convex whorls, the body one of which is ornamented with three, and those of the spire with each two, revolving linear costæ or ridges. The immediate apex is a little obtuse, the sculpture well defined, and the lines of growth minute, or scarcely visible *without the aid* of a magnifier.

Professor Geinitz refers this little shell to the genus *Murchisonia*, but I have elsewhere shown that it possesses neither the labial sinus nor the revolving band of that genus, but that it belongs to the genus *Orthonema* of Meek and Worthen. It is not generally the case that fossil shells of this, or even larger sizes, are found with the lip sufficiently well preserved and exposed to show whether it was provided with a sinus or not; but where the lines of growth can be seen, even by the aid of a magnifier, they enable us at once to decide this question, for in the genera *Murchisonia*, *Pleurotomaria*, and other similar types, these lines always show a curve corresponding to the outline of the sinus. On examining the specimen of this species, loaned to me by Dr. White, under a lens in a cross-light, I could see that the minute lines of growth show no such curve whatever, and that there is no spiral band corresponding to that seen in *Murchisonia*. Several species of this genus from the Coal-Measures of Illinois are also clearly without any traces of either sinus or revolving band.

Specifically, this shell seems to be somewhat related to *O. conica* of Meek and Worthen (Proceed. Acad. Nat. Sci. Philad., July, 1866, p. 270), from the Coal-Measures of Illinois. It is readily distinguished, however, by its more convex whorls, deeper suture, distinct revolving costæ, and the absence of a prominent angle around the base of the body whorl.

Locality and position.—Nebraska City, from bed C of the section at that place; also found by Dr. White at near the same horizon in Western Iowa.

Genus ACLIS, Loven.

ACLIS SWALLOVIANA, Geinitz, sp.

Pl. XI, Fig. 7 *a*, *b*.

Turbonilla (*Loxonema*) *Swallowiana*, Geinitz, 1866, Carb. und Dyas in Nebraska, p. 5, Tab 1, Fig. 19.

Compare *Turritella*?? *Stevensana*, Meek and Worthen, 1866, Ill. Report, Vol. II, p. 382, Pl. 27, Fig. 8; also, *Aclis minuta*, Stevens, 1858, Am. Jour. Sci., Vol. XXV, p. 259; and *Murchisonia minima*, Swallow, Trans. St. Louis Acad., Vol. I, p. 203.

Shell very small, subterete; volutions about seven, increasing very gradually in size; last one not larger in proportion to the gradual increase in the size of the shell than the others, all with a slightly flattened, outward sloping space just below the suture; surface below the flattened upper sloping space ornamented with comparatively distinct revolving lines, of which some five or six may be counted on the body whorl, and three or four on each of those of the spire; lines of growth very fine, and distinctly sigmoid.

Length, 0.15 inch; breadth, about 0.07 inch; angle of spire, about 20°.

I have some doubts in regard to the little shell represented by Fig. 7 *a* being specifically identical with the form figured by Professor Geinitz, since his figure represents the volutions as increasing more rapidly in size, so as to make the angle of the spire near 10° greater. It also represents the body whorl as being more produced below, and shows one or two more of the revolving lines on each of the volutions of the spire. In its general appearance it is more like the *Turritella*?? *Stevensana*, M. & W., though its spire is less attenuate, while its whorls are less numerous, and marked by a smaller number of revolving lines. Supposing Professor Geinitz's figure to be exact, I should think the form it represents, that represented by *our figure 7 a*; and the other described from

the Coal-Measures of Illinois, may possibly belong to three distinct species. The great difficulty, however, of presenting enlarged figures of such small univalves with absolute exactness, is such as to leave doubts on this point, where we have not the means of making direct comparisons of specimens.

I am also in great doubt in regard to the generic affinities of these little shells, and have elsewhere shown that they cannot be properly referred to the recent genus *Turbonilla*, on account of their distinct revolving lines.* The revolving markings are also equally an objection to placing them in the genus *Loxonema*. It is very probable that they will be found to belong to an undescribed genus, when the aperture, lip, columella, &c., can be seen. The group is evidently represented by two or more species in the Coal-Measures of Illinois, one of which was described as an *Aclis* by Dr. Stevens some twelve or thirteen years since, and I even think it very probable that at least the form represented by our figure 7 *a* may be the same species described by Dr. Stevens. At any rate, it agrees with an Illinois specimen that was identified with his species, on comparison by a competent observer with his typical specimen; yet Dr. Stevens distinctly states that his species has twelve of the revolving lines.

Locality and position.—Nebraska City, bed C of the section taken there.

Genus STRAPAROLLUS, Montfort.

STRAPAROLLUS (EUOMPHALUS) RUGOSUS, Hall.

Pl. VI, Fig. 5 *a, b;* and Pl. XI, Fig. 4 *a, b.*

Euomphalus rugosus, Hall, 1858, Iowa Geol. Report, Vol I, Part II, p. 722, Pl. XXIX, Fig. 14 *a, b, c;* (not *E. rugosus*, Sowerby, 1847).

Serpula (Spirorbis) planorbites, Geinitz, 1866, Carb. und Dyas in Nebraska, p. 3, Tab. 1, f. 6; (not of Münster).

Shell small, planorbicular, with upper side concave (viewing it as dextral), and the lower nearly flat, or slightly concave; sometimes with both sides nearly equally concave; volutions four or five, increasing rather gradually in size, not embracing, and all exposed both above and below; all obliquely flattened on the periphery with a narrow ridge or angle around the lower edge, and flattened below; while on the upper side they slope rather abruptly inward from another angle around the upper outer edge, thus giving an irregular subquadrangular outline to the transverse section; aperture subcircular or a little oval within; surface with rather strong marks of growth that impart a rough, or sometimes slightly nodular appearance, to the ridge or angle around the lower outer edge of the periphery.

Breadth of a medium-sized specimen, 0.54 inch; thickness or height of same, 0.16 inch. Specimens are sometimes found, however, of double these dimensions.

As in many other cases, I am compelled to differ with Professor Geinitz, not only in regard to this shell being identical with *Spirorbis planorbites* of the European Permian, but in regard to its being a *Spirorbis* at all. On the contrary, it appears to me to be a mollusk, very closely allied to *Euomphalus*, if not really belonging to that group. The reasons for this opinion are, that, although a very common and widely distributed shell in our Coal-Measures (being often so abundant that hundreds of specimens may be picked up sometimes in an hour or so at a single

* Am. Jour. Sci. and Arts, Vol. XLIV, p. 171, 1867.

locality), not a single one has ever been found, so far as known to the writer, attached by the growth of the shell to any foreign body. Nor have I ever seen, among thousands of specimens, a single one showing any scar or mark of adhesion on either side. In addition to this, we now know, from the same horizon in Illinois, several allied species that no one would think of placing in any other genus, some of which are nearly as large as *E. pentangulatus*, and really connect the form under consideration generically with that shell almost beyond doubt.

In order that this shell may be more readily compared with *Spirorbis planorbites*, as illustrated by Professor Geinitz in his large work on the German Permian fossils, I have copied his figures on our plate VI. By comparing these figures with those of the shell under consideration the differences of form will be at once apparent, especially on comparing our figures 5 *a*, *b*, of the American shell with Fig. 16, *a b c d*, copied from the European form. From these it will be seen that instead of having the dorsal or outer side of its whorls obliquely flattened, as in the American shell, these figures show it to be narrowly rounded or subangular in the middle, and the whole outline of the transverse section of the whorls entirely different, while our shell is *remarkably constant* in this and nearly all of its characters. If required to select from the known European species the form most nearly allied to our shell, I would at once compare it with *Euomphalus quadratus* of McCoy, from the Carboniferous rocks of Ireland. By a glance at our figure 17, representing the last-mentioned species, it will be seen to be really nearly allied to the form under consideration, but still distinct specifically.

Professor Geinitz cites *Spirorbis permianus* and *S. helix* of King (see our figures 15 *a*, *b*, same plate, after Professor King) as synonyms of *S. planorbites*, which would make these, according to his views, also the same as that here described. To me, however, the last-mentioned forms seem to be clearly distinct, not only from the American form, but from the German specimens figured by Professor Geinitz as *S. planorbites*, though the foreign species both doubtless belong to the genus *Spirorbis*.

Locality and position.—The specimens figured on Pl. XI came from division C of the Nebraska City section, at that place. That represented on Pl. VI was found in division B of the same locality. We also found it at Rock Bluff and Aspinwall, on the Missouri, as well as at Cedar Bluff. It is common in the Coal-Measures of Kansas, Missouri, Iowa, and Illinois; being found both in the Upper and Lower Coal-Measures of the latter State, and it likewise occurs in the Lower Coal-Measures of West Virginia. It may also have been this species that Conrad described long back, from the Coal-Measures of Western Pennsylvania, under the name *Inachus catilloides*, as it resembles his figure nearly, though it does not agree so well with his description.

Genus PLEUROTOMARIA, Defrance.

PLEUROTOMARIA HAYDENIANA, Geinitz.

Pl. XI, Fig. 5.

Pleurotomaria Haydeniana, Geinitz, 1866, Carb. und Dyas in Neb., p. 11, Tab. Fig. 15.

Of this little shell I have seen but a single specimen, and in endeavoring to clear it of the adhering matrix, it was broken to fragments. I have, therefore, no means of characterizing it, and merely reproduce Professor Geinitz's figure.

Locality and position.—Division C of the Nebraska City section.

PLEUROTOMARIA PERHUMEROSA, Meek.

Pl. IV. Fig. 13 *a*, *b*.

Shell subovate, not umbilicate; spire and aperture of nearly equal length; volutions about five and a half, increasing rather rapidly in size from the apex, last one comparatively large, and somewhat produced below, all convex, distinctly angular and shouldered, with a shallow, revolving impression on the outer vertical side just below the shoulder; upper side flattened and sloping a little outward from the suture to the nearly rectangular shoulder; suture well defined by the convexity of the whorls, but not channeled; aperture rather large, oval or a little higher than wide, rather narrowly rounded below, and somewhat angular on the upper outer side at the termination of the shoulder of the body whorl sinus of the lip shallow and comparatively wide, placed just above the termination of the shoulder; its revolving band obscure, being neither impressed, raised, nor bounded by lines, extending from the sinus of the lip around the outer margin of the upper sloping flattened side of the whorls, near the angle; surface usually appearing nearly smooth but showing small lines of growth under a magnifier, and a few obscure coarser revolving lines below the shoulder on the body whorl.

Length of largest specimen seen, 0.68 inch; breadth of same, 0.50 inch; angle of spire, 57° to 65°.

I am not acquainted with any species very closely allied to this, those most nearly resembling it in form being marked by more distinct revolving lines. Its most obvious characters are its nearly smooth surface, obscurely defined labial sinus and revolving band, with very distinctly shouldered whorls.

Locality and position.—One mile and three-fourths west of Nebraska City, from a shaft sunk on Hon. J. Sterling Morton's place; also quite abudant at Rulo, Kansas, in Upper Coal-Measures. It also occurs in the Coal-Measures of Illinois.

PLEUROTOMARIA INORNATA, Meek.

Pl. IV, Fig. 14.

Shell elongate, subovate, not umbilicate; spire elevated, conical, nearly twice as high as the aperture; volutions seven, increasing gradually in size, very convex and rounded, with a faint angle a little above the middle, which becomes more distinct on the upper turns, last one not much enlarged, nor extended much below; suture well defined by the convexity of the whorls; aperture oval, being a little longer than wide; sinus of the lip broad, shallow, and placed just above the angle, from which point its flat spiral band revolves immediately above the angle on all the whorls, without being elevated or depressed above the surface, or otherwise strongly defined; surface marked with fine, moderately distinct lines of growth, and very obscure traces of a few revolving lines below the angle of the whorls.

Length, 0.73 inch; breadth, 0.41 inch; angle of spire, about 45°

I am not acquainted with any species very closely allied to this. In some respects it is related to the last; particularly in having both very faint traces of revolving markings, and in the position of its sinus and band just above the angle of its whorls, as well as in the shallowness of its sinus, and the obscurity of its band. It will be at once distinguished, however, by its more slender form, more rounded whorls and their much more obscure angle, which becomes nearly obsolete on

the body volution. It is a rather slender elongated form for a species of this genus, thus approaching the genus *Murchisonia.*

Locality and position.—From Mr. Morton's shaft, one mile and three-fourths west of Nebraska City, where it was found associated with the last, in a bed of clay.

PLEUROTOMARIA GRAYVILLENSIS, N. & P.

Pl. XI, Fig. 9.

Pleurotomaria Grayvillensis, Norwood & Pratten, 1855, Jour. Acad. Nat. Sci., Philad., Vol. III, second series, p. 75, Pl. IX, Fig. 7; Geinitz, 1866, Carbonform. und Dyas in Nebraska, p. 9, Tab. I, Fig. 9.

Not having succeeded in finding specimens of the shell figured by Professor Geinitz under this name, at any of the Nebraska localities, I have merely reproduced his figure. In size, form, and general appearance, as well as in the nature and position of its spiral band, it agrees well with authentic examples of *P. Grayvillensis*, now before me from the Coal-Measures of Illinois. In one respect, however, if carefully drawn, it would seem to differ slightly; that is, in having its revolving striæ of uniform size, instead of consisting of a series of rather distant larger ones, with from about two to four very small ones between each two of the former. This, however, is a character in which shells of this kind often vary, and one that might be overlooked in specimens not showing the surface-marking very clearly.

Locality and position.—Nebraska City, from the upper part of division C of the section exposed there. The *P. Grayvillensis* is widely distributed in the Upper Coal-Measures of Illinois, Kentucky, Iowa, Missouri, Kansas, &c. It occurs in both the Upper and Lower Coal-Measures of Illinois, and in the Lower Coal-Measures of West Virginia.

PLEUROTOMARIA MARCOUIANA, Geinitz.

Pl. XI, Fig. 8.

Pleurotomaria Marcouiana, Geinitz, 1866, Carbonform. und Dyas in Nebraska, p. 10, Tab. 1, Fig. 10.

Having obtained no specimens of this shell in a condition to be drawn, I have carefully copied the figure given by Professor Geinitz. So far as this figure and the specimens obtained afford the means of comparison, I am inclined to regard it as a good species. In some respects it resembles *P. Grayvillensis*, though it is evidently distinct.

Locality and position.—Nebraska City landing, from the upper part of division C of the section.

PLEUROTOMARIA SUBDECUSSATA, Geinitz.

Pl. XI, Fig. 19.

Pleurotomaria subdecussata, Geinitz, 1866, Carbonform. und Dyas in Nebraska, p. 10, Tab. 1, Fig. 11.

This is another species of which I have only seen very imperfect specimens, and hence I have to depend almost entirely upon Professor Geinitz's figure (copied on Pl. XI) for a knowledge of its characters. It belongs to the trochiform section of the genus, including *P. turbiniformis*, M and W., *P. Riddelli*, Shumard, and *P. Missouriensis*, sp. of Swallow, all from the Coal-Measures. It seems, however, to be distinct from all of these, being very much smaller, and differing in the details of its surface-markings.

Locality and position.—*Upper part* division C, Nebraska City.

Genus MURCHISONIA, de Verneuil.

MURCHISONIA NEBRASCENSIS, Geinitz.

Pl. XI, Fig. 6.

Murchisonia Nebrascensis, Geinitz, 1866, Carbonform. und Dyas in Nebraska, p. 12, Tab. 1, Fig. 17.

Of this little shell I have seen no examples, and consequently only know it from Professor Geinitz's description and figure, which latter I have copied, in order to give American students who may not have access to his work the means of identifying it. It belongs to a strongly carinated section of the genus represented by several species (mainly undescribed) in our Western Coal-Measures.

The figure does not show the characteristic sinus of the lip, and the revolving band, of the genus *Murchisonia*; but from the general appearance of the shell, it probably belongs to that genus.

Locality and position.—Same as last.

CEPHALOPODA.

Genus ORTHOCERAS, Auct.

ORTHOCERAS CRIBROSUM, Geinitz.

Pl. XI, Fig. 18 *a*, *b*.

Orthoceras cribrosum, Geinitz, 1866, Carb. und Dyas in Neb., p. 4, Tab. 1, Fig. 5.

This is another form I have not seen from the Nebraska rocks, but i is common in the Upper Coal-Measures of Illinois, and also found i the same position in Iowa, Missouri, &c., and in the Lower Coal-Mea ures of West Virginia. It is probably identical with the Upper Coa Measure species, *O. Knoxense*, of McChesney, or some of the form described, but not yet figured, by Professor Swallow, from the sam horizon, unless the peculiar surface-marking illustrated by Professo Geinitz is really the natural surface ornamentation of the shell. It i far more probable, however, that the pitting seen on Professor Geinitz' specimen is due to some accidental cause, such a style of marking bein very unusual in this genus.

In the Illinois specimens I have seen, these markings are nearly alway on one side only, or more numerous and more strongly defined on one sid than the other, while in other specimens differing in no other respect, could see no traces of them. From these facts I am inclined to thin they were produced by some minute parasites, or boring animals, possi bly on dead shells, as they were lying with one side exposed on the bo tom of the sea.

Locality and position.—Division C of the Nebraska City section; als Upper and Lower Coal-Measures of Illinois, and Lower Coal-Measure of West Virginia.

Genus NAUTILUS, Linn.

NAUTILUS OCCIDENTALIS, Swallow.

Pl. XI, Fig. 17.

Nautilus occidentalis, Swallow, 1858, Trans. St. Louis Acad. Sci., 1, p. 175.
——— *quadrangularis*, McChesney, 1860, Descriptions New Palæozoic Fossils, pp. 65 an 66; illustrations same, 1865, Pl. III, Fig. 5 *a*, *b*.
——— *biserialis*, Hall, 1860, Supp. to Vol. I, part II of Iowa Geological Report, p. 2.

Although we have but the mere fragment of this shell from Nebrask City, figured on Plate XI, I can scarcely entertain the slightest doub

in regard to its identity with the form described by Professor Swallow, under the name *N. occidentalis*, and by Professor McChesney as *N. quadrangulus*, as well as that described by Professor Hall as *N. biserialis*. In this conclusion I am not led by comparisons of descriptions and figures alone, for I have carefully examined Professor Swallow's typical specimen, and have before me good tracings taken by his permission from drawings in his possession of the same. I have also carefully examined good specimens in Mr. Worthen's collection of the same shell, from the same locality and bed from which Professor McChesney's types were obtained.

Like other nodose *Nautili*, *Goniatites*, &c., this shell varies considerably in the prominence and form of its nodes, in different individuals, as well as often in the same individual at different ages, as may be seen by examining the different volutions of the same shell when broken apart. This is also illustrated by the two specimens figured by Professor McChesney. Professor Swallow's type is an internal cast, with less prominent nodes than either of those figured by Professor McChesney.

Well-developed specimens of this species are discoid in form, with a moderately wide, shallow umbilicus, showing nearly all of each inner volution. The whorls present a nearly quadrangular section, the sides and periphery being more or less flattened, with generally a slight concavity around the middle of the latter. Usually there are six rows of nodes; that is, one row of small, depressed nodes on each side around the umbilicus, another larger and more prominent series around each lateral angle of the periphery, and two others on the periphery or outer side. In old specimens those around the margins of the umbilicus are often obsolete, or nearly so. Generally the two rows around the middle of the periphery are smaller and less prominent than those on the lateral angles, and have between them a more or less marked mesial concavity, or furrow. The individual nodes of these two rows are also nearly always alternately arranged, so that those of one row stand opposite the intermediate spaces of the other. In some cases, however, these two mesial rows of the periphery are much more developed than those on the lateral angles, thus giving more convexity to the periphery than where they are smaller. The septa are moderately closely arranged, with a backward curve on the sides and periphery; while the siphuncle is very nearly central.

On specimens retaining the shell intact, very fine, regular lines of growth are seen, which cross the periphery with a rather deep, graceful, backward curve, indicating a deep, rounded sinus in the lip on the outer side.

I am not aware of any perfect specimens of this species having been found. Those figured by Professor McChesney are not entire at the aperture, and measure about 2.50 inches in their greatest diameter, and about 1.30 inches in thickness or convexity. The fragment we have figured from Nebraska City would indicate a size near one-third larger than these.

Locality and position.—Division C of the Nebraska City section. We also saw a fragment of it at a lower position, in the Coal-Measures at Rock Bluff. Professor Swallow's type was found in the valley of Cottonwood Creek, Kansas, in beds referred by him to the Lower Permian, but regarded by Dr. Hayden and myself as Permo-carboniferous. McChesney's specimens were found in the Upper Coal-Measures at Grayville, Illinois, and Mr. Worthen has it from the same horizon at La Salle, Illinois. I have likewise seen fragments of this shell in a small collection belonging to Dr. Stevens, *from the* Coal-Measures near Pittsburg,

Pennsylvania, and I suspect that some of the fragments found by P fessor Stevenson in the Lower Coal-Measures of West Virginia m belong to the same species.

NAUTILUS PONDEROSUS, White, M. S.

Pl. III, Fig. 7 *a*, *b*.

Compare *Nautilus Illinoisensis*, McChesney, 1860, Descriptions New Palæ Fossils, p. 64; also *N. tuberosus*, McCoy, 1855, Brit. Pal. Foss., p. 562, Pl. Fig. 15.

Shell attaining a large size, subdiscoidal; umbilicus large, or ne equaling the dorso-ventral diameter of the outer volution near aperture; volutions three, enlarging their diameter more than tl fold each turn; all broader transversely than dorso-ventrally; i ones slightly embracing, while the last one is apparently merely in tact with the others near the aperture; each broadly flattened or a concave on the periphery, and (particularly the last one) somewhat tened between the periphery and the middle of each side, from w point the sides are broadly rounded into the umbilicus, the greatest t verse diameter being near the middle; ventro-lateral, or outer a of the last whorl (in somewhat worn casts) each provided with ob traces of about twenty wide, undefined nodes, scarcely perceptil the eye; septa numerous, rather closely arranged, making a s backward curve on each side, particularly between the middle an outer angles, and crossing the broadly flattened dorsum with a s backward curve; surface with distinct lines of growth, which (strongly backward like the septa, in crossing the outer side. (uncle unknown).

Greatest diameter of a specimen retaining apparently about one- of the outer chamber, 12 inches; greatest thickness or convexity inches; breadth of umbilicus, 3.75 inches; dorso-ventral diamet the body whorl at the widest part, 3.90 inches. Dr. White's type s men, now in the Iowa State collection, is much larger than that which the above measurements were taken.

This shell seems to be nearly related to *N. Tuberosus* of McC figured in his British Palæozoic Fossils, but differs in the greater (ventral diameter of its whorls, which also increase more rapidly in The nodes of its outer angles are also much smaller and less prom being scarcely perceptible in casts.

I am in some doubt in regard to the generic relations of this sp The propriety of placing any of the old discoid *Nautili*, with a open umbilicus, and distinctly quadrangular volutions, in the sam tion with the recent typhical *Nautilus*, is questionable.

Professor McChesney has not figured the type of his species, *N noisensis*, and I am, consequently, not positively sure that this may r the same, as it agrees pretty well with his description, while I have from La Salle fragments of the form here described.

Locality and position.—Upper Coal-Measures, bed No. 2 of I mouth section. The specimen of *N. Illinoisensis* described by Pro McChesney was found at apparently near the same horizon o Coal-Measures at La Salle, Illinois. The fine specimen figured o plate was obtained by Professor Thomas Egleston from the I mouth exposure, and loaned to me for study and illustration. White's specimen came from the Upper Coal-Measures of Iowa.

ARTICULATA.

CRUSTACEA.

Genus CYTHERE, Müller.

CYTHERE NEBRASCENSIS, Geinitz.

Pl. XI, Fig. 2; and 3 *a*, *b*. ?

Cythere Nebrascensis, Geinitz, 1866, Carb. und Dyas in Nebr., p. 2, Tab. 1, Fig. 2.
—— *Cyclas?*, Geinitz, 1866, *Ib.* Fig. 3 and 4.

Although a number of the carapace-valves of these little crustacea are before me from the same bed in which those figured by Professor Geinitz under these names were obtained, none of them seem to agree *exactly* with his figures, though we undoubtedly have the same form from near the middle of the Upper Coal-Measures in Union County, Iowa, as well as of that he has referred with doubt to *C. cyclas*, Keyserling. The latter seems to me to be only the opposite valve of the *C. Nebrascensis*.

Locality and position.—Division C of the Nebraska City section.

CYTHERE, sp.

Pl. XI, Fig. 1 *a*, *b*, *c*, *d*.

Compare *Cypris subrectus*, Portlock, 1843, Report Londonderry, &c., p. 316, Plate XXIV, Fig. 136.

Carapace-valves oblong-subelliptic in the right valve, and broader elliptic in the left; right valve with dorsal margin straight, or faintly sinuous in outline; interior with a transverse ridge near the posterior end, and an oval depression occupying the whole end just behind it; exterior surface smooth, and usually with a broad, undefined, slightly more convex region at the posterior end, corresponding to the depression within; left valve smooth, most convex behind the middle; interior with a transverse ridge near the posterior end as in the other valve, but having a depression or concavity immediately in front of it as well as behind; dorsal margin a little thickened.

Length, 0.03 inch; breadth of right valve about half the length; breadth of the left about three-fifths the length.

The right valve of this little species agrees very nearly in form with *Cypris subrectus* of Portlock, and might with more propriety be referred to that species than the form, that has been by Professor Geinitz considered doubtfully identical with *C. cyclas* of Keysering, can be referred to that Russian Permian species. The valves of these little crustacea, however, present generally so few characters that not much reliance can be placed on identifications of species, unless by one who has made an especial study of the fossil forms of the group.

Locality and position.—Division C of the Nebraska City section; also associated with the last in the Upper Coal-Measures of Union County, Iowa.

Genus PHILLIPSIA, Portlock.

PHILLIPSIA, sp.

Pl. III, Fig. 1 *a*, *b*.

Phillipsia, sp., Geinitz, 1866, Carb. und Dyas in Nebr., p. 1, Tab. 1, Fig. 1.

I have no specimens of this species for study and description, and therefore merely reproduce Professor Geinitz's figures, in order to present as full an illustration *as possible* of the characteristic fossils of

these rocks. It is probably identical with some of the forms already described, but not yet figured, from the Upper Coal-Measures of the West.

Locality and position.—Upper Coal-Measures, Plattsmouth, Nebraska.

PHILLIPSIA SCITULA, M. & W.

PLATE VI, Fig. 9.

Phillipsia scitula, Meek & Worthen, 1865, Proceed. Acad. Nat. Sci. Philad., p. 270.
Comparo *P. Ciftonensis*, Shumard, 1858, Trans. Acad. Sci. St. Louis, Vol. I, p. 226.

The only specimen of the little trilobite in our collections from Nebraska was not observed until the whole collection had been looked over several times, owing to the fact that it is crushed, and, being incrusted with shaly matter, was placed in a tray with flattened specimens of *Retzia punctulifera*, from the same bed, under the supposition that it was a crushed example of that little shell. On carefully cleaning it, however, it was found to belong to the above species of *Phillipsia*. It was evidently folded with the head and pygidium together, and crushed laterally by accidental pressure, so as to become nearly flat. After careful cleaning, however, it is not difficult to make out enough of its specific characters, by the aid of a magnifier, to leave no doubt of its identity.

It is possible that this is the same form described by Dr. Shumard from the Upper Coal-Measures of Kansas, under the name of *P. Cliftonensis*, but as he only had the pygidium, and had no means of characterizing its other parts, I do not feel warranted in referring it to his species. If they are identical, however, and their identity can be in any way established, his name will have to take precedence, as it was first published.

Locality and position.—Nebraska City, division B. The specimen originally described was from the Upper Coal-Measure at Springfield, Illinois; and it also occurs in the Lower Coal-Measures of that State.

PHILLIPSIA MAJOR, Shumard.

Pl. III, Fig. 2 *a*, *b*, *c*.

Phillipsia major, Shumard, 1858, Trans. St. Louis Acad. Sci., Vol. I, p. 225.

Pygidium semi-elliptical, very convex, a little longer than wide, narrowing posteriorly, the lateral margins being straightened near the middle; posterior extremity narrowly rounded; mesial lobe strongly elevated above the lateral ones, distinctly compressed, and longitudinally furrowed on each side; strongly arched longitudinally, rounded on top, and gradually tapering posteriorly to its rather prominent, somewhat obtuse extremity, which terminates at about one-fifth the entire length of the pygidium from the posterior margin; segments twenty-two or twenty-three, not arching forward or backward, a few of the anterior ones only faintly defined by slender linear furrows, those farther back more distinct, all becoming obsolete on the flattened or furrowed sides of the lobe; lateral lobes wider than the axial one, rounding down abruptly on each side, and sloping more gradually behind, into a smooth border, which continues all around the free margins, but is broader and more flattened behind; segments twelve or thirteen, moderately oblique, very short behind, and gradually increasing in length anteriorly; all ending abruptly on reaching the rather broad, smooth, sloping, marginal zone; surface smooth, or only showing obscure traces of fine granules, with minute scattering pits.

Length of pygidium, 0.77 inch; breadth, 0.72 inch; height, about 0.35 inch.

It is possible that this may be distinct from Dr. Shumard's *P. major*, but it agrees so nearly with his description, that there seems scarcely room to doubt its identity with that species. His type was larger, and proportionally somewhat wider, but agrees well in all its other details, while the slight difference of proportional length and breadth of the pygidium may be due to a difference of age or sex.

It is also closely related to *P. Sangamonensis*, M. & W., described from the Upper Coal-Measures of Illinois, but not only differs in being proportionally a little longer, but also in having its axial lobe proportionally larger. Still it may be the same.

Locality and position.—Dr. Shumard's specimens were from the Upper Coal-Measures of Clinton County, Missouri, and on Vermillion River, 12 miles south of Lecompton, Kansas. Our specimen represented by Fig. 2 *a*, *b*, of Pl. III, was found on the Missouri, in the same horizon at Bellevue, Nebraska. That represented by Fig. 2 *c* was found by Professor Egleston at Plattsmouth.

DESCRIPTIONS OF FOSSIL FISHES FROM THE UPPER COAL-MEASURES OF NEBRASKA.

By Orestes H. St. John.

Genus CLADODUS, Agassiz.

Cladodus mortifer, N. and W.

Pl. III, Fig. 6 *a*, *b*, and Pl. VI, Fig. 13 *a*, *b*, *c*, *d*.

Cladodus mortifer, Newberry and Worthen, Geol. Illinois, Vol. II, p. 22, Pl. I, Fig. 5; St. John, 1870, Proceed. Am. Philos. Soc., Vol. XI, p. 431.

In the collection there are fragments of three individuals of the above species—two showing the base with portions of the crown, and one preserving about a third of the lower portion of the median cusp of a very large specimen. There can be no doubt that the teeth before me are referable to the above species; but as they exhibit characters not shown in the imperfect specimen figured and described by Messrs. Newberry and Worthen, a short description of the Nebraska teeth is here appended.

Description.—The base of the tooth is semi-elliptical in outline, obtusely angular behind, with low protuberances rising at the angles upon the superior inner margin, the outer margin interrupted by a broad, shallow sinus, at either angle of which, immediately beneath the smaller lateral denticles, an obtuse node projects downward, similar to those upon the upper opposite side of the root, the presence of which would seem to have been designed to lend additional strength to the muscular attachment of the tooth upon its cartilaginous support; median cone cervical, regularly tapering, recurved, inequally compressed, with acute lateral edges; striæ sharp, interrupted, separated by wide plane spaces, less numerous upon the strongly compressed anterior face, and confined to the lower half of the cusp; lateral denticles two upon either side, strong, with sharp cutting edges, and strong sharp striæ or ridges.

Breadth of base twice its length, and equal to the entire height of the tooth.

This species, so far as we at present know, is restricted to the Upper Coal-Measures. The *single type specimen* from which the species was

originally described was found in the Upper Coal Strata near Springfield, Illinois; and in the prosecution of the geological survey of Iowa, Dr. White has brought to light the same species from the Upper Coal-Measures of the southwestern portion of the State. I have also found this species in the same formation at Manhattan, Kansas.

Compared with other species, the present one is probably more closely related to *C. mirabilis*, Agassiz, from the Mountain Limestone, Ireland, than with any other to which I am acquainted. It differs, however, in being less robust, and more symmetrical in its general proportions.

Formation and locality.—Upper Coal-Measures, bed B, Nebraska City section, Nebraska.

Genus DIPLODUS, Agassiz.

DIPLODUS COMPRESSUS, Newb.

Pl. IV, Fig. 19 *a*, *b*.

Diplodus compressus, Newberry, Geol. Illinois, Vol. II, p. 60, Pl. IV, Fig. 2; St. John, 1870, Proceed. Am. Philos. Soc., Vol. XI, p. 432.

The single specimen of *Diplodus* in the collection is probably referable to the form described by Dr. Newberry under the name *D. compressus*.

Description.—The tooth is of medium size; base slightly narrower than long, broadly rounded in front, and terminating in an obtuse point behind; under surface slightly raised in the middle; anterior extremity produced into a large obtuse tubercle projecting slightly outward and downward, with a flattened, sharply defined, obovate, pad-like projection upon the upper surface of the posterior extremity, marked upon either side by a shallow groove terminating above in a little pit, which is entirely separated from the bases of the crown cusps; in this latter respect, as Dr. Newberry has remarked, offering marked contrast to *D gibbosus*, Agassiz, from the Mountain Limestone of Europe; cusps three median one rudimentary, slender, compressed, with finely crenulated lateral edges, base well defined from the general surface and terminating in a slight protuberance in the osseous root in front; the apices of the lateral cusps are broken away in the specimen before me; they are strongly compressed, smooth, with sharp, beautifully crenulated cutting edges, unequally divergent; left one—viewed from before—most inclined from a vertical line and broadest at base; transverse section of both lenticular.

In the collection of the Iowa State geological survey, there is a tooth from the Upper Coal-Measures of Southwestern Iowa, which is doubtless specifically identical with the Nebraska specimen, though possessing some slight differences. In the Iowa specimen the base has, as in the above-described tooth, a lozenge-shaped outline, its posterior extremity is more abruptly truncated, and the pad-like elevation surmounting its surface is elliptical with its longer axis transverse to the root—in other respects the same as the Nebraska tooth; viewed in front, the right lateral cone is the strongest and most inclined laterally, and the bases on the anterior face are swelled out, producing an angular ridge or buttress, which, however, is lost both in the crown above and in the root below. These two individuals are the only ones I have had opportunity to examine, and comparing them with the excellent description and figures of *D. latus*, Newb., I cannot doubt but that they are distinct from that species. The present species is described from the Coal-Measures of Ohio and Southwestern Indiana, the latter locality holding a stratigraphical position probably below the Nebraska horizon.

Formation and locality.—Upper Coal-Measures, Rulo, Nebraska.

Genus PETALODUS, Agassiz.

PETALODUS DESTRUCTOR, N. and W.

Pl. III, Fig. 5.

Petalodus destructor, Newberry and Worthen, Geol. Illinois, Vol. II, p. 35, Pl. II, Figs. 1, 2, 3; St. John, 1870, Proceed. Am. Philos. Soc., Vol. XI, p. 433.

The collection contains a large, almost perfect specimen of the above species, which presents the following characters:

Description.—The crown is sharp, compressed, gradually thickening toward the base; crest more or less gently arched from the lateral extremities, obtusely acuminate at the apex, and distinctly striated for the space of a line or less, below which the striæ are lost in the dense enamel-like coating which covers both faces of the crown; posterior face of crown rhombic, outline of base similar to that of crest, and bordered by five strongly marked imbricating folds, which are conspicuously arched downward in the middle, and more or less deflected at the lateral extremities; anterior face broadly rhomboidal, basal fold consisting of four or five obscurely marked imbrications, gently curved downward in the middle, and again at the lateral extremities; the upper edges of the imbricating folds are minutely crenulated; root broad, compressed at the edges, rapidly tapering from the lateral shoulders, and terminating in a blunt rounded point. Upon much-worn surfaces the crown is finely punctate.

	Inches.
Length, nearly	2.00
Greatest breadth of crown, about	1.60
Height of anterior face of crown	0.95
Height of posterior face	1.28
Breadth of root across the lateral shoulders, about	1.10

This species bears a striking resemblance to *Petalodus acuminatus*, Agassiz, from the Mountain Limestone of Europe; but, at the same time, it possesses characters which readily distinguish it from that species. The present species differs mainly in the more tapering root, the coronal band upon the inner face is more strongly curved downward in the middle, and the crown is relatively higher. This species was originally described from the Upper Coal-Measures of Central Illinois. I have seen a fine specimen of the same species in the collections of the museum at Cambridge, from similar horizons in Southwestern Indiana, and also from the Upper Coal-Measures of Central Iowa.

Formation and locality.—Upper Coal-Measures, Rock Bluff, Nebraska.

Genus PERIPRISTIS, Agassiz, M. S.

Peripristis (Agassiz), St. John, Proceed. Am. Philos. Soc., Vol. XI, p. 434.

Generic characteristics.—Teeth small or of medium size, possessing the general characteristics of the petalodonts. Crown compressed, acuminate, serrate, more or less curved laterally; extremities on the inner face connected by a raised transverse shoulder, in which the crown terminates below, and which gives rise to a more or less profound coronal cavity. Root well developed, entire, as in *Petalodus*. The surfaces of the crown and coronal cavity are covered by a dense and highly polished layer of ganoine, which forms an imbricated band at the base.

The above generic designation was suggested by Professor Agassiz for the reception of a group of peculiar teeth, of which we have at least

two representative species—that of *P. semicircularis* being regarded as the type. These forms certainly possess features which are widely at variance with the typical species of the genus *Ctenoptychius*, as represented by *C. apicalis*, Agassiz; and in their description of the following species, Messrs. Newberry and Worthen have also referred to the remarkable characters which distinguish it from the typical species of *Ctenoptychius*. The central coronal cavity and the prominent transverse ridge in which the root is terminated above on the posterior aspect are peculiarities which do not appear in any of the numerous other genera comprised in the groups of petalodonts.

The genus is Carboniferous, ranging from the Lower Carboniferous to the Upper Coal-Measures inclusive.

PERIPRISTIS SEMICIRCULARIS, N. & W., sp.

Pl. III, Figs. 3, 4; and Pl. IV, Fig. 20 *a*, *b*.

Ctenoptychius semicircularis, Newberry and Worthen, Geol. Illinois, Vol. II, p. 72, Pl. IV, Figs. 18, *a*, *b*.

Description.—Tooth small, broadly obovate in outline, crown much compressed and strongly curved laterally, giving the crest a semicircular outline viewed from above; cutting edge divided into seven to nine denticulations, the median lobe strongest, lateral ones gradually decreasing in size toward the lateral extremities, where they are scarcely relieved from the edge; the calcigerous tubes slightly diverge on nearing the edge, producing a minute radiated striation of the denticulations like that observed in the even crest of *Petalodus*, and when the crown is much worn the surface is finely punctate; outer face of crown very low in proportion to its breadth, base sharply beveled, coronal band narrow, imbrications very obscure or obsolete, gently descending in the middle, and slightly curved downward at the lateral extremities; upon the posterior face the base of the crown is defined by a conspicuous transverse ridge, which unites the lateral extremities, and gives origin to a deep central coronal cavity; the enamel-like coating lines the walls of the cavity, and, spreading over the gently and regularly downward arched transverse shoulder, it forms a thin coronal band with one or two faint imbrications upon its external inflexed border. The root is nearly as wide and much thicker than the crown, tapering rapidly, and rounded at its extremity; anterior side convex or ridged, posterior face slightly concave transversely; both surfaces more or less roughened.

	Inches
Greatest length	0.7
Greatest breadth at the lateral angles of the crown	0.7
Height of crown upon its anterior face	0.3
Depth of the coronal cavity from the apex of the median denticulation, about	0.4
And from the transverse shoulder, about	0.2

The collection contains a perfect specimen of the above-described species, from Bellevue, Nebraska, imbedded in a matrix of limestone, but exhibiting the entire posterior aspect of the tooth without a blemish and I owe to the kindness of Hon. J. Sterling Morton, of Nebraska City another equally perfect specimen, obtained from a shaft excavation near the city, which shows the anterior face of the tooth. I think there can be no question as to their specific identity with the form described by Messrs. Newberry and Worthen from the Upper Coal-Measures of Illinois.

I am acquainted with but a single other form to which this species seems to be closely related, and that is from the Mountain Limestone of Yorkshire, England. Specimens of the latter species are in the extensive collections of the Museum of Comparative Zoölogy at Cambridge. The English specimens are, however, markedly distinct specifically from the American; they are less curved laterally, and possess some sharp, thick serrations on either side of the median cusp; the crown is relatively higher, and the coronal band on the outer face is more deeply arched downward in the middle, is wider and more distinctly imbricated; the coronal cavity of the inner face is shallower, and the transverse shoulder less prominent. I am not aware that the English species is described.

Formation and locality.—Upper Coal-Measures; Rockbluff and Bellevue; and from Morton's Shaft near Nebraska City, Nebraska.

GENUS CHOMATODUS, Agassiz.

CHOMATODUS ARCUATUS, St. John.

Pl. VI, Fig. 14 *a*, *b*.

Chomatodus arcuatus, St. John, 1870, Proceed. Am. Philos. Soc., Vol. XI, p. 435.

A fragment of limestone from Bennett's Mill, near Nebraska City, preserves the impression of a tooth of the genus *Chomatodus*, which seems to be distinct from all the species of this genus heretofore described from the Coal-Measures and Lower Carboniferous. The impression presents almost the entire figure of the anterior face, from which the following description is given:

Description.—Tooth large, laterally elongated, moderately thick (?), extremities rounded; crown slightly arching from the lateral angles and curved laterally; anterior face slightly convex vertically and rounded at the crest, which was probably more or less obtuse; the anterior face of the crown was apparently undulated along its crest; the obscure sulci may have reached half the distance from the crest toward the base, and at the median line a very shallow depression, about as high as it is wide at the base, reaches upward about two-thirds the height of the crown, and seems to interrupt the continuity of the basal folds, which, however, may not be persistent or of specific importance; basal band narrow, linear, with two or three imbricated folds, and parallel with the base of the root; surface coarsely punctate. Root nearly as wide as the crown, its anterior face deeply channeled by an angular transverse furrow, with a low ridge traversing the lower portion from one extremity to the other, below which it is beveled to the outer basal edge.

	Inches.
Greatest breadth, about	1.60
Height	0.50
Greatest height of anterior crown face	0.22

In outline the above species bears a somewhat marked resemblance to *C. loriformis*, N. and W., from the Keokuk limestone; but it differs from that form in having the anterior face of the crown relatively higher, its crest undulated and less parallel, and its bow-shaped outline viewed from above as well as in the more vertical concavity of the outer aspect of the root. It is not improbable that the basal angle of the posterior crown face was quite prominent, and the vertical concavity of that face of the crown must have been considerable, judging from the arched character of the opposite face, and *in this respect* somewhat resembling C. cinctus,

Agassiz, though the present species is not acuminate, the coronal l not nearly as wide as in that species, and the tooth is not as thick massive.

Formation and locality.—Upper Coal-Measures, Bennett's Mill, Nebraska City; where it was found in place by the writer.

GENUS XYSTRODUS, Agassiz, M.S.

XYSTRODUS? OCCIDENTALIS, St. John.

Pl. IV, Fig. 18 *a*, *b*, *c*, *d*.

Xystrodus? occidentalis, St. John, 1870, Proceed. Am. Philos. Soc., XI, p. 43

The collection affords an interesting little deltoid tooth, which lieve has not been heretofore described. Unfortunately, the spe is quite imperfect, and, although its specific characters permit of de tion, its generic affinity remains somewhat in doubt.

Description.—Terminal tooth small, subtrigonal in outline, little rower than long, but slightly enrolled, flattened or gently depr above; the straight side is abruptly beveled, and from its edg crown gently inclines to the opposite oblique margin, which is slightly raised; the border extremity is thickened, forming a well-d continuous marginal border, which rapidly descends upon the inne and gently slopes into the shallow, depressed space in front; towa terminal extremity the tooth becomes exceedingly thin, and in the men before me the pointed end and outer margin are broken away. superior surface is coarsely punctate, as is also the straight articula gin. Distance between the angles of the broader extremities, 0.38

The tooth above described possesses some characters which se connect it more closely with *Xystrodus*, Agassiz, M.S., than wit other genus with which I am acquainted. Its general depresse urating surface, and but slightly convoluted terminal extremity strongly suggestive of this relation. The genus *Xystrodus* was lished by Prof. Agassiz for the reception of *Cochliodus striatus* an or more other European species from the Mountain Limestone.

Formation and locality.—Upper Coal-Measures, Aspinwall, Nebr

DELTODUS? ANGULARIS, N. and W.

Pl. VI, Fig. 18 *a*, *b*.

Deltodus angularis, Newberry and Worthen, Geol. Illinois, Vol. II, p. 97; Pl. IX, St. John, 1870, Proceed. Am. Phil. Soc., Vol. XI, p. 437.

Description.—Terminal tooth small, obliquely triangular in ou thick, but slightly enrolled; the broader extremity has a sigmoidal ture, terminating in an acute point at the oblique posterior extre straight side forming an angle of about 55° with the oblique m abruptly truncated, with a narrow sulcus about the middle of th eled articular face extending from the inner angle to the pointe below which the tooth apparently expands into a thin, narrow l similar to that upon the opposite side; the articular margin is bor by a prominent, flattened ridge, which occupies about one-third th face of the crown and gradually narrowing as it approaches the nal point; a sharp, narrow keel rises from the oblique margin, r converging and decreasing in prominence toward the apical en *separated from* the broad, flattened prominence of the straight m

an equally broad, deep, angular furrow; along the oblique side the
ɔth was slightly expanded into a thin marginal border. The crown
rface is beautifully granulo-punctate, the broader extremity very
ntly marked by longitudinal sigmoid lines of growth, and the broad
ɔsial depression is traversed by very obscure undulations parallel with
e oblique keel. Under surface longitudinally undulated, smooth.
Length of tooth along the straight margin, about 0.52 inch; greatest
stance between the acute and obtuse angles of the broader extremity,
18 inch.

The collection affords but a single example of this handsome form.
ıe specimen before me has a remarkable resemblance to the posterior
eth of *Deltoptychius*, Agassiz, M.S., founded upon *Cochliodus acutus*
the Irish Mountain Limestone; but we do not at present possess the
aterials fully to demonstrate this identity. The Nebraska tooth, how-
'er, is evidently identical with the form described by Messrs. Newberry
ıd Worthen, from stratigraphically corresponding horizons in Illinois;
ıd Dr. White has discovered the same, or a very closely allied species,
the Upper Coal-Measures of Southwestern Iowa.

Formation and locality.—Upper Coal-Measures, bed B, Nebraska
ity: where it was discovered by Dr. White.

PART III.

ENTOMOLOGY,

BY

S. H. SCUDDER.

OTES ON THE ORTHOPTERA COLLECTED BY DR. F. V. HAYDEN IN NEBRASKA.

By SAMUEL H. SCUDDER.

I.—LIST OF THE SPECIES OBSERVED IN NEBRASKA.

GRYLLUS NEGLECTUS, Scudd.—Abundant along the Platte, up Loup Fork, Pawnee Reserve.

GRYLLUS PERSONATUS, Uhl.—A few specimens were taken on the banks of the Platte.

NEMOBIUS VITTATUS, Harr.—The specimen obtained seems to be referable to Harris's species; it was found on the banks of the Platte.

ŒCANTHUS NIVEUS, Sew.—Judging from poor specimens, this seems to be identical with our eastern species—1 ♂ 1 ♀. Banks of the Platte.

CEUTHOPHILUS GRACILIPES. Scudd. (?)—3 ♂ 1 ♀, mostly immature, were taken at Nebraska City.

IDEOPSYLLA ROBUSTA, Scudd.—3 ♂ 3 ♀, from Nebraska City and the banks of the Platte.

XIPHIDIUM SALTANS, nov. sp.—Similar to *X. brevipennis*, Scudd., but with much shorter wings. In the male the stridulating field occupies one-half of the tegmina. The projection of the vertex is unusually great; the ovipositor is very long and slender, slightly curved. ength from tip of vertex to extremity of abdominal segments, 0.5 inches; length of tegmina, ♂ 0.14 inch, ♀ 0.06 inch; length of hind femora, 0.41 inch; length of ovipositor, 0.52 inch.

♂ 1 ♀ from the banks of the Platte.

ONOCEPHALUS ATTENUATUS, nov. sp.—Tubercle of vertex bordered beneath with black, long, slender, conical, bluntly pointed, with a slight basal tooth on the under side; tegmina very slender, pointed at the tip, more than twice the length of the abdomen; hind legs slender, the femora furnished beneath, externally, with a row of exceedingly short and fine, distant, spinous hairs; internally with a row of four or five very short and distant spines, directed backward; ovipositor very slender, barely reaching the tip of the wing-covers at rest.

ngth of tubercle, measured beneath, 0.08 inch; length of hind femora, 0.85 inch; length of tegmina, 2 inches; length of ovipositor, 1.3 inches.

, 2 ♀, and several immature specimens were taken on the banks of the Platte.

NABRUS SIMILIS, nov. sp.—This species is very closely allied to *A. purpurascens*, Uhl.; it differs from the latter principally in its slightly shorter and more curved ovipositor.

ngth of pronotum, 0.46 inch; length of hind tibiæ, 0.74 inch; length of ovipositor, 0.72 inch.

3 ♀. Banks of the Platte.

10. OPSOMALA BIVITTATA, Serv.—2 ♀ from Nebraska City.
11. BRACHYPEPLUS MAGNUS, Girard.—1 ♂ 8 ♀. One specimen from Nebraska City, the remainder from the banks of the Platte.
12. STENOBOTHRUS GRACILIS, nov. sp.—Vertex of the head broad, swollen, with elevated anterior border; foveolæ extremely shallow, long, triangular, with the base toward the eye; lateral carinæ of pronotum rather prominent, regularly curved, approximate in the middle; median carina slight; hind border of pronotum a little angulated; middle of the lower border produced into a rounded projection.

    Slightly mottled, pale reddish brown, a band of the deeper tint just behind the eyes, bordered above by the yellowish lateral carinæ of the pronotum; tegmina nearly uniform in color, but with two or three small spots in the central field.

    Length from vertex to tip of tegmina, 0.65 inch. 1 ♂ taken on the banks of the Platte.
13. ACRIDIUM EMARGINATUM, Uhl, MSS.—Pronotum light greenish red, lighter on sides; a distinct yellow band from the vertex of the head to the tip of the pronotum; antennæ yellowish, changed into brown at tips; tegmina brownish-red, inner border margined with dull yellowish; hind femora yellowish, with a few black points on the upper outer carina; hind tibiæ dark brownish-red, armed with black-tipped, yellow spines; abdomen yellow, with transverse rows of black dots at the tips of the segments.

    Length from vertex to tip of tegmina, ♂ 1.4 inches, ♀ 1.75 inches. 3 ♂ 3 ♀ along the banks of the Platte River.
14. CALOPTENUS FEMUR-RUBRUM, Burm.—1 ♂ 2 ♀ only were collected, from Rulo, Southern Nebraska, July 9th; from Nebraska City and from the banks of the Platte River. For further remarks on this species see below.
15. CALOPTENUS SPRETUS, Uhl.—Rulo, Southern Nebraska, on the banks of the Missouri River, in great quantities, July 9th; other specimens were brought from the banks of the Platte River and from Nebraska City. For further remarks on this species see the second division of my paper.
16. CALOPTENUS BIVITTATUS, Uhl.—1 ♂ 3 ♀, taken along the banks of the Platte River and at Nebraska City.
17. PEZOTETTIX SPECIOSA, nov. sp.—Pronotum rugose, the anterior half with irregular transverse, the posterior half with irregular longitudinal lines; the raised portions pale yellowish; the depressed parts deep reddish; tegmina immaculate, yellowish, with the longitudinal vein of inner half pinkish.

    This species is placed here provisionally, as it does not strictly appertain to *Pezotettix*.

    Length of pronotum, ♂ 0.23 inch, ♀ 0.30 inch; length of tegmina, ♂ 0.4 inch, ♀ 0.6 inch; length of hind femora, ♂ 0.56 inch, ♀ 0.8 inch.

    1 ♂ 2 ♀ from Nebraska City and the banks of the Platte River.
18. ŒDIPODA TRIFASCIATA.—*Gryllus trifasciatus*, Say. Amer. Entom. Pl. XXXIV. 1 ♂ from Nebraska Territory.
19. ŒDIPODA COLLARIS, nov. sp.—Dark reddish-brown; lower half of head, base of hind femora, and a broad band along the posterior edge of the pronotum, pale clay-yellow; hind tibiæ reddish; tegmina mottled somewhat uniformly with fuscous blotches, which form three distinct bands, the outer of which is sometimes lost in the nearly equal mottling of the tip; wings pale yellow at base, some-

what obfuscated at tip with a broad median blackish band, occupying the middle third of the wing at the costal border, crossing the wing at right angles with uniform breadth, (excepting a spur thrown out toward the base, as in *Œ. xanthoptera*,) and then, with decreasing width, following the curve of the wing to the inner angle; pronotum with a prominent median ridge throughout its extent.

Length from vertex to tip of tegmina, ♂ 1.2 inches, ♀ 1.6 inches; 2 ♂ 2♀ from Nebraska City and from the banks of the Platte.

0. ŒDIPODA TENEBROSA, nov. sp.—Nearly uniform dark fuscous, front of head with somewhat pale markings; pronotum above dull, dirty yellow, with dots and streaks of fuliginous; hind femora banded with yellow just before the tip; hind tibiæ with a dull reddish band next the base, followed by a darker band; tegmina almost uniformly mottled with fuscous, the outer half interspersed with paler spots; wings, pale reddish at base, the whole outer border obscured by a broad, dark, fuliginous band, slightly paler at the extreme tip, projecting sharply inward almost to the base of the wing, near the costal margin; antennæ fuscous, basal third paler; pronotum with a slightly raised median carina.

Length from vertex to tip of tegmina, ♂ 1.2 inches, ♀ 1.25 inches; 2 ♂ 2 ♀, Nebraska City and along the banks of the Platte.

1. ŒDIPODA HALDEMANII, nov. sp.—This species is closely allied to *Œ. corallipes*, Hald., but differs from it in the greater rugosity of the pronotum and in the greater separation and distinctness of the markings on the tegmina. The wings are pale yellow at base, hyaline with black veins at tip and across the middle, have a rather narrow fuliginous band, curving regularly around to the inner angle, broken at the division of the central and inner areas of the wing, and above this projected strongly and broadly inward, almost to the very base of the wing; at the costal border the band becomes almost piceous.

Length from vertex to tip of tegmina, ♂ 1.25 inches, ♀ 1.8 inches; 1 ♂ 4 ♀, Nebraska City and the banks of the Platte.

2. ŒDIPODA CAROLINA, Burm.—2 ♂ 5 ♀ from Nebraska City and the banks of the Platte.

3. DIAPHEROMERA VELII, Walsh.—1 ♂ 1 ♀ from the banks of the Platte River.

4. STAGMATOPTERA MINOR, nov. sp.—This little *Mantis* is a miniature of *S. carolina*, but, on a front view, the vertex of the head is less swollen and, indeed, nearly flat; the eyes are not so prominent, and instead of being regularly rounded, are slightly flattened above, in continuation of the contour of the vertex; head and pronotum mottled with black and dark, dirty yellowish, the pronotum with raised black points along the outer border; tegmina dark brown, obfuscated on the apical half; stigma of the same color as its surroundings and therefore inconspicuous.

Length of pronotum, 0.25 inch; length of tegmina, 0.28 inch; breadth of head, including eyes, 0.17 inch.

Three specimens from Nebraska City.

5. TEMNOPTERYX MARGINATA, nov. sp.—Pronotal shield piceous, bordered laterally with a wide yellowish band; furnished, also, with a few widely and irregularly scattered punctulations; tegmina piceo-ferruginous, the outer margin with a yellowish band in continuation of that on pronotal shield, reaching half-way to the apex; femora beneath luteous; *tibiæ and tarsi* castaneus.

Length of pronotal shield, 0.17 inch; breadth of the same at the terior border, 0.22 inch; length of tegmina, 0.26 inch; breadt the same in the middle, 0.16 inch.
From the banks of the Platte.

II.—REMARKS ON THE DEVASTATING GRASSHOPPERS NORTH AMERICA.

At least three kinds of migratory grasshoppers, two of which b to the genus *Caloptenus*, are found in the United States.

One, *Caloptenus femur-rubrum*, Burm., is found in all the State of the Mississippi, unless we except the southernmost, as well those bordering it on the west. It was long ago described by De This seems to be the least destructive kind, and only on extraord occasions has been known to migrate in clouds, or even extend it ages over a wide stretch of country.

The second, *Caloptenus spretus*, Uhl., a much more destructiv cies, occurs over the whole of the vast region west of the States b ing the Mississippi, to the very base of the Rocky Mountains, Texas on the south, past the boundaries of the United States, t Saskatchewan River on the north. The species, which receive name in manuscript from Mr. Uhler, has been briefly described b Walsh. This entomologist discusses at length, in the Practical mologist for October, 1866, the probability of its permanent footh Kansas and Nebraska. While we agree with him in his conclu we would by no means assent to a line of argumentation founded his hypothesis of its origin. "It is evidently a strictly alpine in says Mr. Walsh. He bases this assertion solely upon the stateme Drs. Velie and Parry, who assured him that, in Colorado, "it bre the mountains, and comes down into the settlements in vast sw through the cañons, or deep perpendicular cuts, leading from the n tains to the more level country." Mountain valleys, with a sou exposure, will, however, breed animals which perhaps could not e the rigors of the open plain, so that this evidence lacks suffici Moreover, we have two facts of a different nature—first, that regions outside the natural limits of the range of this pest are inv the inclemency alone of a succeeding spring can prevent the eg newly hatched young from coming to maturity; secondly, that the i has often bred, year after year, in a region south of, and much m than Kansas and Nebraska, viz, Central Texas. The actual limit of its natural abode I do not know, nor have we as yet sufficient for a reasonable hypothesis. Indeed, we ought to be supplied wi extensive series of simultaneous observations made over the wh the ravaged districts, stating the exact time and direction of each f and the direction of the wind at the time. By collating these da might be able to arrive at some clear conclusions concerning the nal habitation of the species.*

* Since this article left my hands, Mr. Walsh has reiterated his arguments, great deal of force and originality, in the American Entomologist, Vol. I, pp. and in his First Annual Report on the Noxious Insects of the State of Illin 82–103. The former article, however, has brought out the adverse statement observers in Colorado, the seat of the grasshoppers, (see American Entomologi 94–95,) one of whom, Mr. Byers, states explicitly that it is "common to western or *rainless* region, one-third of the United States, but its breeding-pl upon the hot, parched plains and table-lands, from four to six thousand feet abo sea, instead of in the cañons of the mountains. The greater the heat the mor flourish."

A third species of grasshopper, unnamed as yet, belonging to the genus *Œdipoda*, appears to be the insect which has ravaged the cultivated districts of California and Oregon, and the neighboring States and Territories; it probably ranges over the whole extent of country west of the Rocky Mountains and included within the limits of the United States. Mr. A. S. Taylor, in one of his articles in the California Farmer, subsequently communicated to the Smithsonian Institution and published in their Report for 1858, describes the grasshopper as found near Monterey, and it is doubtless the migratory species which ravaged the State. It is a species of *Œdipoda*, which, from the devastating nature of its ravages, may be called *Œdipoda atrox*, or the terrible grasshopper.* To the best of my knowledge, it is the only species of the genus which has anywhere proved seriously and persistently injurious to crops. Several species of the closely allied genus *Pachytylus* have ravaged the fields of Eastern Europe and Asia; and it is interesting, in a zoölogical point of view, to find that California, whose insect fauna bears a much more general resemblance to the peculiar types of the Old World than to those characteristic of the opposite border of the New World, should in this case also harbor a devastating grasshopper so much more nearly allied to the destructive species of the Mediterranean than to those found upon the same continent with itself.

For the elucidation of the history of these three species, and to show the similarity of their devastations, I have brought together all the original matter I could obtain, as well as a few already published statements, and will present them under the heading of each species.

A.—CALOPTENUS FEMUR-RUBRUM, Burmeister.

Its ravages in New England.—Although the ravages of locusts in America are not followed by such serious consequences as in the Eastern Continent, yet they are sufficiently formidable to have attracted attention, and not unfrequently have these insects laid waste considerable tracts, and occasioned no little loss to the cultivator of the soil. Our salt-marshes, which are accounted among the most productive and valuable of our natural meadows, are frequented by great numbers of the small red-legged species, (*Acrydium femur-rubrum*,) intermingled occasionally with some larger kinds. These, in certain seasons, almost en-

*We subjoin a description of this species:

ŒDIPODA ATROX, nov. sp.—Head uniform, pale brownish yellow; the raised edge of the vertex dotted with fuscous; a dark fuscous spot behind the eye, broadening posteriorly, but not extending upon the pronotum. Antennæ as long as the head and pronotum together, dull honey-yellow, growing dusky toward the tip. Pronotum dark-brownish yellow, the sides darker anteriorly; median carina extending the whole length of the pronotum, moderately raised, cut once by a transverse line a little in advance of the middle; lateral carinæ prominent, extending across the anterior two-thirds of the pronotum; anterior border of the pronotum smooth, very slightly angulated; posterior border delicately marginate, bent at a very little more than a right angle, the apex rounded; tegmina dull-yellowish on the basal half, with distinct fuscous spots; toward the apex obscurely fuscous, with indistinct fuscous markings; humeral ridge yellowish, and, when the tegmina are in repose, inclosing a brownish fuscous triangular stripe; the spots are scattered mostly in the median field, consisting in the basal two-fifths of the tegmina of small roundish spots and one larger longitudinal spot in the middle of the basal half; there is a large irregular spot in the middle of the tegmina, and beyond a smaller transverse spot, followed by indistinct markings; wings hyaline, slightly fuliginous at the extreme tip; the veins, especially in the apical half, fuscous; legs uniform brownish fuscous; apical half of spines of hind tibiæ black.

Length of body, 0.9 inch; of tegmina, 0.9 inch; of body and tegmina, 1.125 inches; of pronotum, 0.2 inch; of hind femora, 0.5 inch.

It bears a strong resemblance to *Œdipoda pellucida*, Scudd., common in Northern New England.

tirely consume the grass of these marshes, from whence they then take their course to the uplands, devouring, in their way, grass, corn, and vegetables, till checked by the early frosts, or by the close of the natural term of their existence. When a scanty crop of hay has been gathered from the grounds which these puny pests have ravaged, it becomes so tainted with the putrescent bodies of the dead locusts contained in it that it is rejected by horses and cattle.

At various times they have appeared in great abundance in different parts of New England. It is stated that, in Maine, during dry seasons they often appear in great multitudes and are the greedy destroyers of the half-parched herbage. In 1749 and 1754 they were very numerous and voracious; no vegetables escaped these greedy troops; they even devoured the potato tops; and in 1743 and 1756 they covered the whole country and threatened to devour everything green. Indeed, so great was the alarm they occasioned among the people, that days of fasting and prayer were appointed on account of the threatened calamity. The southern and western parts of New Hampshire, the northern and eastern parts of Massachusetts, and the southern part of Vermont, have been overrun by swarms of these grasshoppers and have suffered more or less from their depredations.

Among the various accounts which I have seen, the following, extracted from the Travels of the late President Dwight, seems to be the most full and circumstantial:

Bennington, Vermont, and its neighborhood, have for some time past been infested by grasshoppers of a kind with which I had before been unacquainted. At least, their history, as given by respectable persons, is in a great measure novel. They appear at different periods, in different years: but the time of their continuance seems to be the same. This year (1798) they came four weeks earlier than in 1797, and disappeared four weeks sooner. As I had no opportunity of examining them, I cannot describe their form or their size. Their favorite food is clover and maize. Of the latter they devour the part which is called the silk, the immediate means of fecundating the ear, and thus prevent the kernel from coming to perfection. But their voracity extends to almost every vegetable, even to the tobacco plant and the burdock. Nor are they confined to vegetables alone. The garments of laborers, hung up in the field while they are at work, these insects destroy in a few hours; and with the same voracity they devour the loose particles which the saw leaves upon the surface of pine boards, and which, when separated, are termed saw-dust. The appearance of a board fence, from which the particles had been eaten in this manner, and which I saw, was novel and singular; and seemed the result, not of the operations of the plane, but of attrition. At times, particularly a little before their disappearance, they collect in clouds, rise high in the atmosphere, and take extensive flights, of which neither the cause nor the direction has hitherto been discovered. I was authentically informed that some persons employed in raising the steeple of the church in Williamstown, were, while standing near the vane, covered by them, and saw, at the same time, vast swarms of them flying far above their heads. It is to be observed, however, that they customarily return and perish on the very ground which they have ravaged.

Through the kindness of the Rev. L. W. Leonard, of Dublin, New Hampshire, I have been favored with specimens of the destructive locusts which occasionally appear in that part of New England, and which, most probably, are of the same species as the insects mentioned by President Dwight. They prove to be the little red-legged locusts, whose ravages on our salt-marshes I have already recorded.

In the summer of 1838, the vicinity of Baltimore, Maryland, was infested by insects of this kind; and I was informed by a young gentleman from that place, then a student in Harvard College, that they were so thick and destructive in the garden and grounds of his father, that the negroes were employed to drive them from the garden with rods; and in this way they were repeatedly whipped out of the grounds, leaping and flying before the extended line of castigators like a flock of fowls. Some of these insects were brought to me by

the same gentleman, on his return to the university, at the end of the summer vacation, and they turned out to be specimens of the red-legged locusts already mentioned.—(*Dr. T. W. Harris, in his Report upon the Insects of New England Injurious to Vegetation.*)

Its ravages on Cape Cod.—In some dry seasons within my recollection they have been so numerous here as to destroy almost every green thing. I am not able to give the precise year when their depredations were committed; I only know that in times of great drought their ravages have been very great.—(*From an account by Mr. F. Scudder, Barnstable, June 22, 1868.*)

Its ravages in Maine.—The year 1821 or 1822 was an unusually dry season during the summer months. In the early part of the season fires had raged extensively on newly cleared lands. In June there appeared an immense number of red-legged locusts (*Acridium femur-rubrum*) on the farm where I then resided in the town of Pownal, Cumberland County, Maine.

The land is a light sandy soil, in places merging into a sandy loam, which, but a few years before, had supported a dense growth of spruce and hemlock; this had been burned over, leaving the ground covered with a heavy scurf of vegetable matter. It was apparently in this scurf that the locusts had laid their eggs the previous year.

During the haying season the weather was dry and hot, and these hungry locusts stripped the leaves from the clover and herdsgrass, leaving nothing but the naked stems. In consequence, the hay crop was seriously diminished in value. So ravenous had they become that they would attack clover, eating it into shreds. Rake and pitchfork handles, made of white ash, and worn to a glossy smoothness by use, would be found nibbled over by them if left within their reach.

As soon as the hay was cut and they had eaten every living thing from the ground, they removed to the adjacent crops of grain, completely stripping the leaves; climbing the naked stalks, they would eat off the stems of wheat and rye just below the head, and leave them to drop to the ground. I well remember assisting in sweeping a long cord over the heads of wheat after dark, causing the insects to drop to the ground, where most of them would remain during the night. During harvest-time it was my painful duty, with a younger brother, to pick up the fallen wheat heads for threshing; they amounted to several bushels.

Their next attack was upon the Indian corn and potatoes. They stripped the leaves and ate out the silk from the corn, so that it was rare to harvest a full ear. Among forty or fifty bushels of corn spread out in the corn-room, not an ear could be found not mottled with detached kernels.

While these insects were more than usually abundant in the town generally, it was in the field I have described that they appeared in the greatest intensity. After they had stripped everything from the field they began to emigrate in countless numbers. They crossed the highway and attacked the vegetable garden. I remember the curious appearance of a large flourishing bed of red onions, whose tops they first literally ate up, and, not content with that, devoured the interior of the bulbs, leaving the dry external covering in place. The provident care of my mother, who covered the bed with chaff from the stable-floor, did not save them, while she was complimented the next year for so successfully sowing the garden down to grass. The leaves were stripped from the apple-trees. They entered the house in swarms, reminding one of the locusts of Egypt, and as we walked they would rise in countless numbers and fly away in clouds.

As the nights grew cooler, they collected on the spruce and hemlock stumps and log fences, completely covering them, eating the moss and decomposed surface of the wood, and leaving the surface clean and new. They would perch on the west side of a stump where they could feel the warmth of the sun, and work around to the east side in the morning as the sun reappeared. The foot-paths in the fields were literally covered with their excrements.

During the latter part of August and the first of September, when the air was still dry, and for several days in succession a high wind prevailed from the northwest, the locusts frequently rose in the air to an immense height. By looking up at the sky in the middle of a clear day, as nearly as possible in the direction of the sun, one may descry a locust at a great height. These insects could thus be seen in swarms, appearing like so many thistle-blows as they expanded their wings and were borne along toward the sea before the wind; myriads of them were drowned in Casco Bay, and I remember hearing that they frequently dropped on the decks of coasting vessels. Cart-loads of dead bodies remained in the fields, forming in spots a tolerable coating of manure.

It was an object of curiosity to me, then a boy, to catch some of the largest locusts, and turn up their wings to find the little red parasite which covered their bodies; this might have done something toward hastening their destruction, although it did not prevent the ravages on the crops.

During the years necessary to clear up the forests on the sandy lands in the vicinity, it was no uncommon thing to have the crops seriously injured by these locusts, but never, to my knowledge, to the extent described above.

In response to my special inquiries concerning the flight of these insects, my correspondent replied as follows:

I do not remember ever to have witnessed the flight of these grasshoppers to any extent, except during the year mentioned, and the preceding one. Nor do I ever recollect a time when the wind blew so steadily for days in succession, from the northwest, generally rising soon after mid-day, and going down with the sun. I have no meteorological record, but speak from memory.

The town of Pownal was principally settled after the opening of the present century. As the lands were cleared, the Canada thistle and other species sprang up in great quantities; when they ripened, the winds spoken of as occurring at that time carried off immense numbers of the thistle-blows to the ocean. I was wont to spend hours in my boyhood lying on the ground and directing my eyes as near as I could to the sun, to watch the thistle-blows as they passed across or near its disk. I think I could have seen them in this situation several hundred feet high. I injured my eyes permanently by indulging in this amusement. Whether the grasshoppers ever rose to so great a height I do not know, but I think that they generally flew at a lower level. * * * Although they would rise in clouds as one approached them, it was only an occasional one that would rise higher, and fly off before the wind, and then only when the wind was blowing freshly. They did not fly with their heads directly before the wind, but seemed to rise in the air, set their wings in motion, and suffer themselves to be borne along by the current. They generally, perhaps always, rose in the afternoon, when the sun was hot and the wind blowing freshly.—(*From accounts furnished by Dr. N. T. True, Bethel, Maine, February 28 and March 10, 1868.*)

Its ravages in Ohio and Pennsylvania.—Mr. Schenck, of Franklin, Warren County, Ohio, writes to the Ohio Farmer that the grasshoppers

are making their appearance in vast numbers. He says, "Last year we had millions of them; this year we have hundreds of millions." For five years, he says, they have been increasing on his farm, and he fears that unless some means are discovered for their destruction they will totally ruin his own and his neighbors' clover-fields.

The speed of the Central Railroad locomotives is considerably decreased by the immense swarms of grasshoppers between Lancaster and Philadelphia. One engineer stated that his train was forty minutes behind, owing to the number of grasshoppers on the track, and that he used twenty buckets of sand, which was thrown on the rail in front of the driving-wheels, to enable him to get along at all. Improbable as this story may appear, its truth is vouched for by the engineer above alluded to.—(*Quoted by Mr. A. S. Taylor in the California Farmer, April* 22, 1859.)

B.—CALOPTENUS SPRETUS, Uhler.

Notes upon CALOPTENUS SPRETUS, *Uhler, as observed during its invasion of Western Iowa in August and September*, 1867.

By September 3, these grasshoppers had reached the vicinity of Redfield, in the central part of Dallas County, and were sufficiently numerous to attract general attention. I first detected them September 1st, while collecting insects in the afternoon. The next day they were very common, and on the day succeeding rose before me in my walks in swarms. At this time I did not notice their arrival in immense flights, but in Guthrie County, in the valley of the Beaver, they were said to have appeared in *myriads* at about 11 a. m., September 5th, coming from the northwest and alighting so thickly as literally to cover the ground. They gradually dispersed, and after a day or two were much less common. At noon of the 13th I observed the lighting of an immense flight, in the same vicinity, likewise coming from the northwest. They filled the air quite thickly, and, with their wings glistening in the sunlight, resembled immense snow flakes. Their progress was readily traced from the north and west, and their origin was undoubtedly Dakota and Nebraska, where my friend Mr. O. H. St. John observed them in abundance in the larval state, in May. He also noticed them at or near Sioux City, and at other points on the Iowa side of the Missouri River. Their progress eastward was gradual; they appeared at Exira, in Audubon County, only forty or fifty miles west of Redfield, about August 20th, or nearly two weeks earlier than at the latter place.

After a few days their havoc with the vegetation began to be painfully apparent; in ten days they had stripped the leaves from the corn, the potatoes, and the white-willow hedges; several species of *Ambrosia* and *Chenopoda* presented but bare stems, and even the resinous foliage of the *Helianthi* did not wholly escape. I was obliged at once to suspend for the season my herbarial collections, from the ragged condition of the foliage of almost all species. Yet they displayed discrimination in selecting their food, leaving sorghum wholly untouched while denuding maize growing by its side; melons themselves were eagerly devoured while the vines that bore them were scarcely mutilated; every cabbage patch was quickly disposed of; they even attacked the *ears* of corn, eating off the outer husks, and devouring an inch or more of the end of the ear.

They commenced pairing soon after their arrival, but oviposition was delayed for some days. I think the exact time of this may depend upon the weather, or rather upon the condition of the ground. For a

time after their arrival the weather was intensely dry—the culmination of a very protracted and severe drought. Although they commenced pairing a week or ten days previously, none were seen depositing their eggs until the occurrence of a heavy rain, which moistened and of course somewhat softened the hard, parched ground. This happened on the 17th, when oviposition became at once general, and was being carried on in every favorable place when I left the State, September 23d.

For breeding sites they generally select spots devoid of vegetation, preferring paths, road-sides, and other hard, bare ground, the compactness of the earth in such places doubtless tending to preserve the eggs from being crushed, or from disturbances to which in loose earth they would be liable. Into this hard ground the female, by diligent working, inserts her somewhat extensible abdomen its whole length, making a cylindrical cavity about an inch and one-half in depth. At the bottom of this the eggs are laid; they form a mass three-fourths of an inch to an inch in length, and about one-fourth of an inch in diameter. The eggs are elongated, fifteen to twenty-five in number, and when first laid are of a light yellow color, which soon deepens almost to an orange. Around the eggs a quantity of white or light-pinkish frothy substance is deposited, which soon hardens to form a compact egg-case. Usually the hole is filled with it, the summit of the egg-case being about half an inch or more below the surface. Ordinarily the holes are nearly vertical, but sometimes more or less inclined. During oviposition, as at other times, these grasshoppers are eminently gregarious; every bare space of ground of considerable size is completely covered with them, and each square inch made the receptacle of several clusters of eggs; the surface of the ground appears thickly perforated with small holes.

It is difficult to give a just conception of their numbers. Any one who has once seen them would feel no surprise in hearing of locomotives stopped in rising grades by their abundance on the rails, as actually happened in Iowa. The tires of ordinary vehicles were covered with their crushed remains, while it was impossible to walk without treading upon them; swine feasted upon them, especially when they were slightly stiffened by cold in the early morning; hazel and other slender bushes I have seen bending under their weight; and closely-grazed hill-sides appeared as white as though sown with plaster from the glistening of their wings. They were most partial to cultivated districts; the vicinity of valleys along the streams was next in favor. On the high, broad, wild prairie they were rarely met with, and I never saw them in such places in numbers sufficient to attract attention.

I left the invaded district too soon to state their duration. At New Jefferson, in Greene County, September 22, I saw immense numbers in the air, as though new accessions were coming; at the same time the ground was thickly strewn with the dead. Apparently they live but a very short time after depositing their eggs. So far as I could learn, they did not proceed eastward beyond the middle of the State.

Two other invasions of Western Iowa by immense numbers of a migratory grasshopper—probably this same species—have occurred since its settlement: one three years ago, when they only devastated the western tier of counties; the other ten years previous to that, when they swept over the entire State, although, from all accounts, in less numbers than recently. In both cases they deposited their eggs, and greatly terrified the inhabitants by their prospective abundance. In both cases the eggs were hatched during the following spring, but while the larvæ were very young cold rains came on and destroyed them all. *Hence this spring* the farmers of Iowa may in like manner be relieved

of them; if not, their ravages during the coming summer must be fearful. It was the universal testimony that this species of grasshopper is not ordinarily seen in Iowa. Indeed, nearly every one with whom I conversed claimed never to have seen it before.—(*From an account furnished by Mr. J. A. Allen, Cambridge, Massachusetts, March* 10, 1868.)

Its ravages in British America.—Three kinds of grasshoppers made their appearance here in 1864 and 1865: 1st, a grasshopper yellow on the belly, and about three inches in length, stout in proportion. From one of these I pressed out as many as one hundred eggs; there were very few of this species, [probably *Œdipoda corallipes*, Hald., which occurs at Red River.] 2d, a grasshopper one and one-half inches in length with two yellow stripes, commencing at the antennæ and running down on the upper wings, meeting at the tips when the wings are closed. I have dug up some of their nests and found sixty-two eggs in one, and as many as seventy-two in another; this species was not very numerous. [*Caloptenus bivittatus*, Uhler.] 3d, the kind which I now forward, [*Caloptenus spretus*, Uhl.] The male is one inch in length; the female from one and one-fourth to one and one-half inches in length; they deposit from twenty to thirty-one or thirty-two eggs in a nest. They visited here in 1857, laying their eggs in great numbers, in the Assinniboin region, destroying the crops of 1858. In 1864 and 1865 they came again in swarms and destroyed many fields. The eggs deposited in 1865 produced their young from the 20th of May to the 10th of June, and moulted for the last time from the 20th of July to the 10th of August; a few days after they fled away. On the 12th of last August (1867) they fell in immense numbers, swarm following swarm, until late in September; as soon as they fell they commenced the work of reproduction, which they continued during August and September, and the first week of October; this labor performed, they took their flight to the south. A correspondent at Carleton House, on the Saskatchewan River, in speaking of these grasshoppers, says, "The day in which you say they made their appearance at Red River, (August 12, 1867,) I left Carleton House for Fort Pit, (on the north branch of the Saskatchewan River,) and all along the route they were very numerous; about the latter end of August they were flying south in great numbers." They also occurred last autumn at Fort Pelly, in the Swan River district, (near the head-waters of the Assiniboin,) and they have doubtless deposited their eggs in all the barren ground (prairie) between Fort Pit and Red River. They did not extend to the Winnipeg River, but myriads of them were drowned in Lakes Mantowaba and Winnipeg.—(*From a letter of Mr. Donald Gunn, Red River, April* 17, 1868.)

Its ravages in Nebraska.—The last day of August, 1866, near the middle of the afternoon, quite a number of grasshoppers were seen alighting, and that number rapidly increased till a little before sunset. The next morning they appeared much thicker, but were only so from having crawled more into the open air to sun themselves. About 9 o'clock they began to come thicker and faster from a northerly direction, swarming in the air by myriads, and making a roar like suppressed, distant thunder. By looking well up to the sun they could be seen to good advantage, and could be seen as high as the eye could discover an object so small, in appearance like a heavy snow-storm, each hopper very much like a very large flake, save that it passed by instead of falling. The number was beyond imagination—the leaves of the timber in this section of the Territory would be but little in comparison. The air was literally full of them, and continued so till along in the afternoon, when the air was free of them; countless millions having passed on, leaving

other countless millions covering the earth to devour vegetation. Sunday and Monday being cloudy and damp, they contented themselves by devouring every eatable thing that came in their way; but Tuesday brought a repetition of the scene of Saturday. Since then they have not flown so much, and at this writing there are millions of them in this neighborhood, fortunately working their way a little east of south. * *

Their present visitation may be for some good, but I am too blind to see it. Their ravages here have drawn down many a hearty yet uncouth expression of disgust and hate from honest and hard-working farmers. Go into the gardens and see them stripped of nearly every vestige of vegetation, both stock and fruit; go into the field and see the vines of all sorts stripped of all their leaves, and eaten to the ground; go and see the corn, as completely naked as if some violent storm had torn every blade from the stalks, leaving it looking like a lot of degenerate hoop-poles; go into the orchards and timber, and see many of the smaller trees, especially, almost bare, the leaves having been devoured by these ravaging creatures. Many a sad sight and many a downcast countenance now fill the roll.—(*Mr. S. C. Maxima, quoted by Mr. B. D. Walsh in the Practical Entomologist, October*, 1866.)

Its ravages in Kansas.—The grasshoppers sent herewith are popularly known as the "Mormon," "Western," or "Colorado" grasshopper. Last month they made their appearance in the frontier settlements of Kansas and Nebraska. To-day I was expecting specimens to send you, and they came—not a pill-box full, but in clouds. As high as the eye could reach, the air was filled with them; and they came down glittering in the sunlight like huge flakes of snow, and at once commenced their vocation of destroying every green thing. Indian corn, however, seems their favorite food, and they promise to be as destructive to it as their neighbors, the spearmen, (*Doryphora decemlineata*,) have been to the potato. On the Nemaha the late corn has been entirely destroyed by them. Even where some men hastily cut up and shocked their corn, the grasshoppers continued their depredations until only the bare stalk remained. Wheat, when sown, was eaten up if left uncovered.

In many places the ground is fairly honey-combed by their egg-cells, which are from three-tenths to five-tenths of an inch in depth. The common length of the egg-cells is one and three-tenths of an inch; but by calling on a number of boys for a large one and a small one, I found the extremes to be one and six-tenths and nine-tenths of an inch.—(*Professor W. I. Robertson, quoted by Mr. B. D. Walsh in the Practical Entomologist, October*, 1866.)

Its ravages in Minnesota.—For two years in succession—in 1856 and 1857—the grasshoppers destroyed our crops, and many resolved then to keep two years' supply of produce on hand afterward. One fact I noticed: although they ate the bark from saplings and consumed our corn, tobacco, &c., ate holes in clothes hanging out to dry, and destroyed boots and shoes when they lit on them in the house, yet pease they avoided, and it was an odd sight to see the fields stripped, even of the weeds, and the pea patch left undisturbed.—(*Mr. O. H. Kelley in the Country Gentleman, quoted by Mr. B. D. Walsh in the Practical Entomologist, October*, 1866.)

C.—ŒDIPODA ATROX, Scudder.

Its ravages on the Pacific coast.—The Sacramento Union of the same date (July, 1855) states that the "most remarkable circumstance we have ever been called on to notice in this locality was the flight of

the grasshoppers on Saturday and yesterday. For about three hours, in the middle of the day, the air, at an elevation of about two hundred feet, was literally thick with them, flying in the direction of Yolo. They could be the more readily perceived by looking in the direction of the sun. Great numbers fell upon the streets on Saturday, absolutely taking the city by storm, and yesterday they commenced the wholesale destruction of everything green in the gardens of the neighborhood. Their flight *en masse* resembled a thick snow-storm, and their depredations the sweep of a scythe."

The Shasta Courier, printed in the Northern Sacramento Mountains, remarks that "on Wednesday last (September 19, 1855) an immense flight of grasshoppers passed over this place, flying westward. The greater portion of them flew very high, and could only be seen by shading the eyes from the sun. They were as thick in the heavens as flakes of snow in a winter's storm."

The Sacramento Valley papers mention that whole orchards, gardens, and vineyards have been consumed by them. Entire fields of young grain, of crops and vegetables, have been eaten up within the space of a single day, leaving the ground like a wilted, blackened desert. In some parts of the valley they annoyed the passengers and horses of the public stages to such an extent as to cause the greatest inconvenience, and appear in some cases to have positively endangered human life.

A gentleman who resided in Colusa County, in the Sacramento Valley, in the summer of 1855, informs me that these insects appeared to rise out of the eastern boundaries of the valley, where it is hot, dry, and sandy, and that on some days they filled the air so as to obscure the sun. They consumed all garden vegetables, the leaves and bark of the elder-tree, and the young leaves and bark of the small branches of the cotton-wood and willow, and even the soft, green parts of the tules or bullrushes. In Stony Creek, in the same county, their dead bodies were seen at one time completely covering the surface of the water for miles in extent. In some parts of this valley they ate through gauze and textile coverings of all kinds, which had been used to shield animals and plants from their attacks.—(*Mr. A. S. Taylor in the Smithsonian Report for* 1858, *and in part in the California Farmer, January* 15, 1858.)

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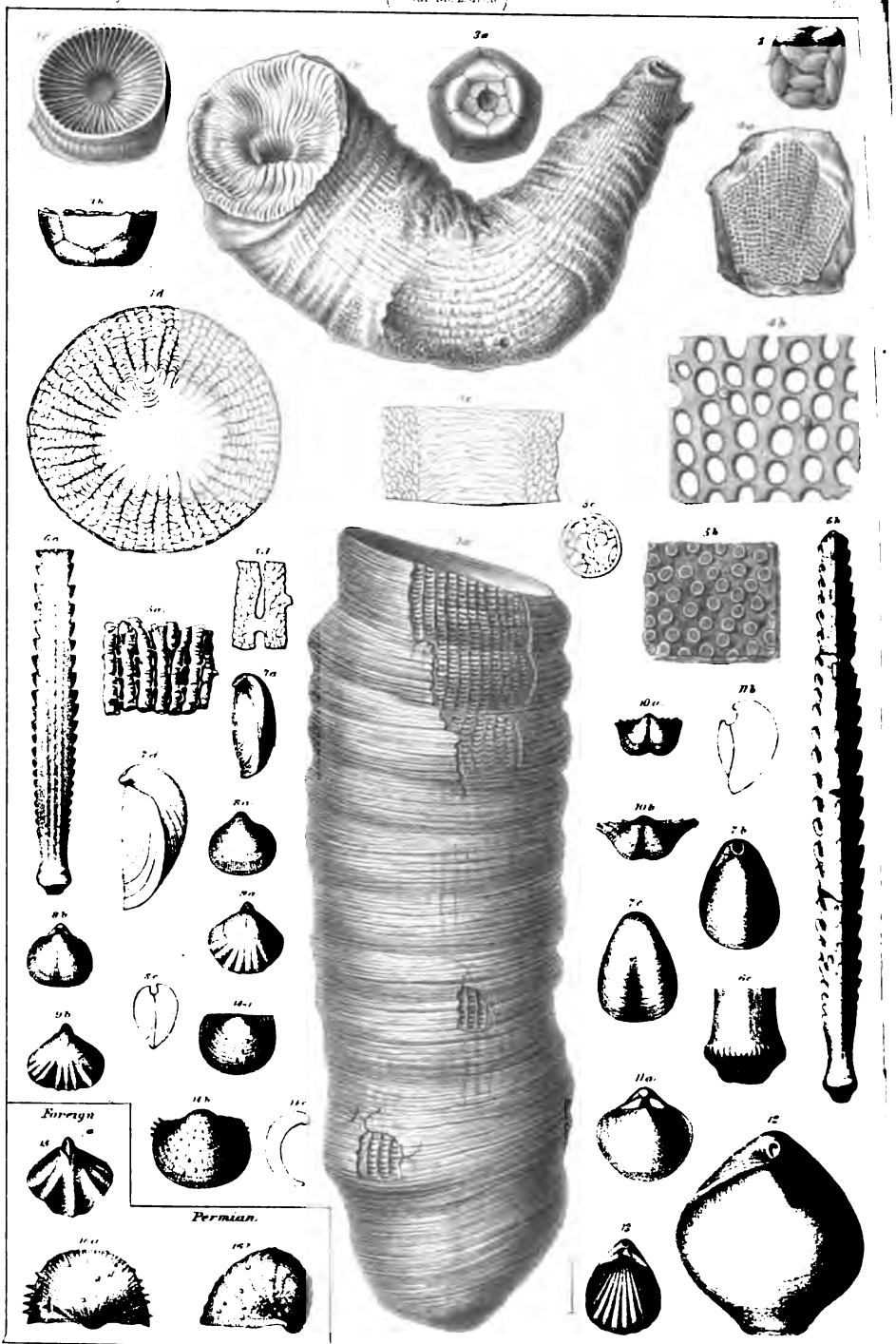
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EXPLANATIONS OF PLATE I.

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1.—CAMPOPHYLLUM TORQUIUM 145

1*a*. A nearly straight part of a large specimen, incomplete at both extremities, slightly reduced in size. (Rock Bluff.)

1*b*. A smaller flexuous specimen, side view, showing also the calice with its margins broken away; one-eighth diameter less than natural size. The epitheca is eroded in places so as to expose the septa.

1*c*. A small specimen showing the calice nearly complete, with a small septal fossula above, and a round central depression.

1*d*. Transverse section of the large specimen, showing the two sets of septa, the thin dissepiments between, and the central area occupied by the smooth tabulæ. The short septum above indicates the position of the fossula.

2.—FUSULINA CYLINDRICA 140

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3.—ERISOCRINUS TYPUS 146

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3*b*. A side view of the same.

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4*a*. A portion slightly reduced from Professor Geinitz's figure representing the natural size.

4*b*. Non-poriferous side a little reduced from Professor Geinitz's magnified figure of same.

5.—SYRINGOPORA MULTATTENUATA 144

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5*b*. A transverse section of a portion of the corallum where the corallites are rather widely separated; one-eighth diameter less than natural size.

5*c*. Transverse section of one of the corallites magnified so as to show the very short septa around the wall, and sections of the irregular tabulæ within.

5*d*. Longitudinal section of a portion of two of the corallites, a little magnified, showing the oblique irregular tabulæ.

6.—ARCHÆOCIDARIS? TRISERRATA 151

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6*b*. The opposite side of another specimen, magnified slightly less than two diameters, showing a mesial and two lateral serrated carinæ.

6*c*. A portion of the articulating end of the same, enlarged about four diameters, to show its milled ring and minute longitudinal striæ.

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8*a*. Ventral view of a rather large specimen slightly less than natural size.

8*b*. Dorsal view of same.

8*c*. Outline profile view of same.

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9*b*. Ventral view of same, showing it to be a true *Rhynchonella*.

10.—CHONETES VERNEUILIANA 170

10*a*. The usual form, and a little less than the natural size, of the species.

10*b*. Another *specimen unusually* extended on the hinge line.

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11*b*. Outline profile view of same.

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A rather large, well-developed specimen, dorsal view.

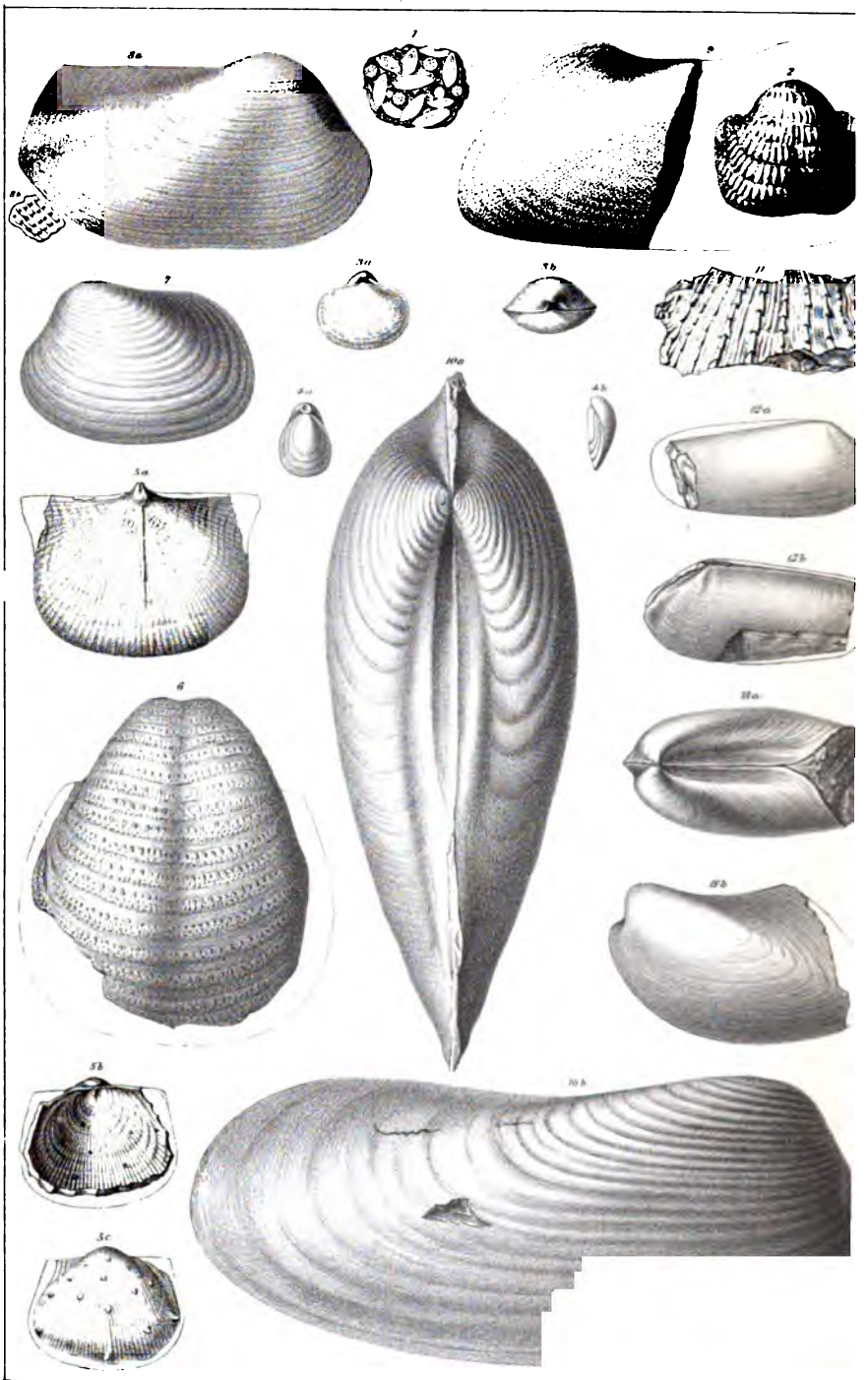
Fig. 13.—RETZIA (EUMETRIA) PUNCTULIFERA 181
Dorsal view, magnified rather less than two diameters.

Fig. 14.—PRODUCTUS PERTENUIS 164
14*a*. View of a cast of the outside of the concave or dorsal valve, one-eighth diameter less than natural size.
14*b*. View of outside of ventral valve of another specimen about natural size.
14*c*. Section in outline of the two valves united, showing the distinct concavity of the dorsal valve.

FOREIGN SPECIES FOR COMPARISON.

Fig. 15.—CAMAROPHORIA SCHLOTHEIMI 179
An internal cast (slightly reduced in size from Professor King's figure), showing (at *a*) the cast of the rostral chamber, separated by the deep slit on each side left by its walls. For comparison with Fig. 9*b*, in which there are no traces of the walls of such a chamber.

Fig. 16.—PRODUCTUS CANCRINI 165
16*a* & *b*. Posterior and lateral views, slightly reduced from de Verneuil's figure; for comparison with Fig. 14.



EXPLANATIONS OF PLATE II.

Page.

Fig. 1.—FUSULINA CYLINDRICA 140
A fragment of limestone, showing sections of *Fusulina*, one-eighth diameter less than natural size. (Rock Bluff.)

Fig. 2.—PRODUCTUS NEBRASCENSIS 165
A cast of the interior of a ventral valve (reduced one-eighth diameter in size) as seen when broken from a hard limestone matrix, so as to leave the shell and spines in the latter. (Bellevue.)

Fig. 3.—SPIRIFER LINEATUS ?*
3*a*. Dorsal view of a small specimen of the shell divested of its minute hair-like spines.
3*b*. Same, cardinal view. (Platte River.)

Fig. 4.—TEREBRATULA BOVIDENS 187
4*a*. Dorsal view of a small specimen, of nearly natural size.
4*b*. Profile view of same. (Rock Bluff.)

Fig. 5.—PRODUCTUS PRATTENIANUS 163
5*a*. Interior of an imperfect dorsal valve from Plattsmouth, showing the mesial ridge, and very short cardinal process (nearly natural size).
5*b* & *c*. Dorsal and ventral views of a smaller specimen, from Rock Bluff, with the ears, margins, and spines broken away (a little less than natural size).

Fig. 6.—PRODUCTUS PUNCTATUS 169
An imperfect ventral valve, partly exfoliated, so as to remove the small spines, ears and margins. A little less than natural size. (Plattsmouth.)

Fig. 7.—EDMONDIA SUBTRUNCATA 215
View of cast of left valve, one-eighth diameter less than natural size. (Rock Bluff.)

Fig. 8.—ALLORISMA (SEDGWICKIA) GRANOSA 220
View of right valve; mainly a cast, but with some remaining portions of shell. One eighth diameter less than natural size. (Rock Bluff.)

Fig. 9.—CHÆNOMYA LEAVENWORTHENSIS 216
Posterior portion of the two valves united. Slightly less than natural size. (Rock Bluff.)

Fig. 10.—ALLORISMA SUBCUNEATA 221
10*a*. Dorsal view of an internal cast of a large specimen, one-eighth diameter less than natural size.
10*b*. Side view of same. (Rock Bluff.)

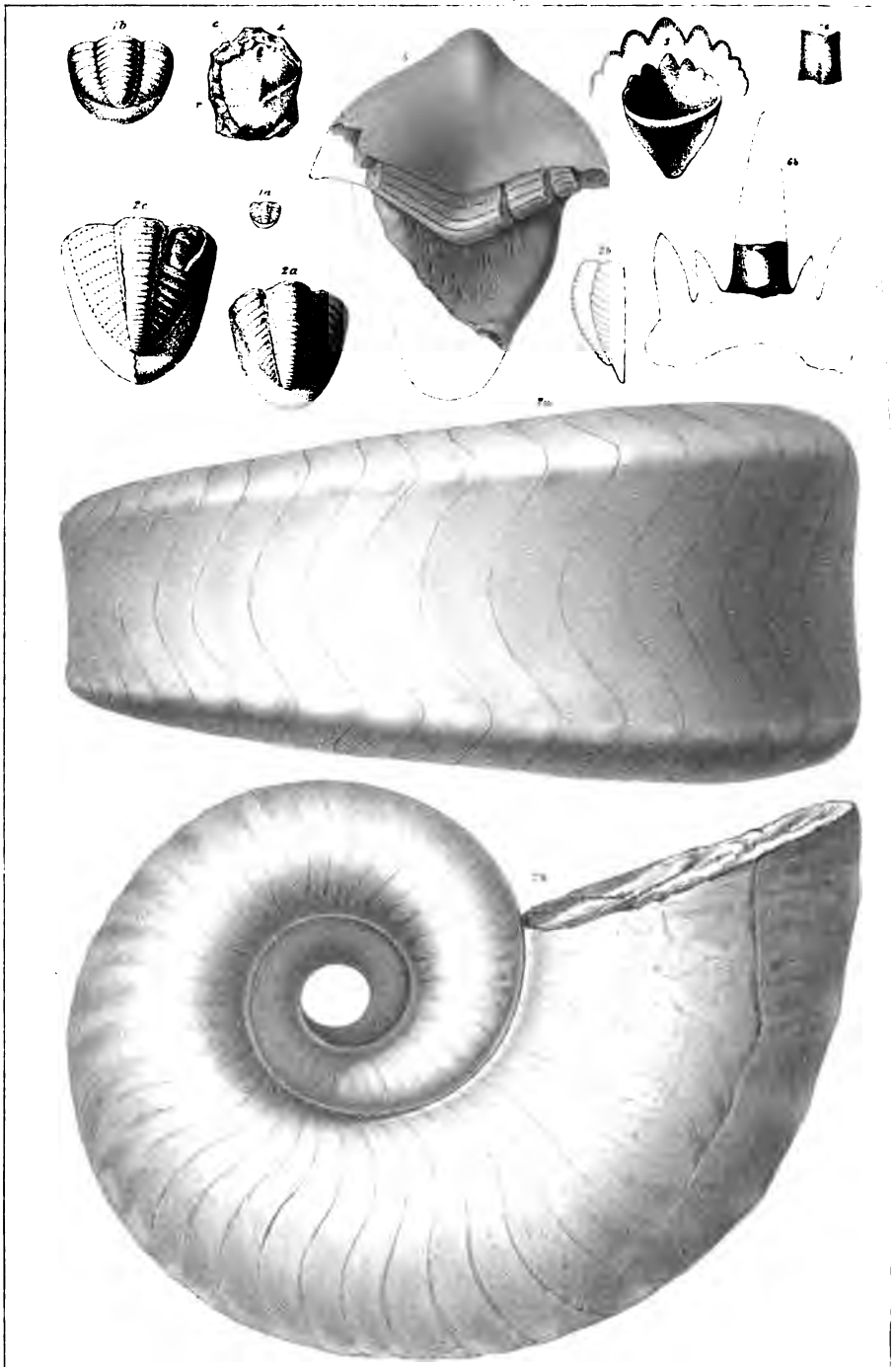
Fig. 11.—PSEUDOMONOTIS, sp 200
A fragment of a left valve (cast) showing the larger costæ, with vaulted scale-like laminæ of growth, and smaller ribs between; slightly reduced in size. (Cedar Bluff.)

Fig. 12.—SOLENOMYA, sp.†
12*a*. An imperfect cast, slightly reduced in size.
12*b*. Opposite view of same. (Rock Bluff.)

Fig. 13.—CHÆNOMYA MINEHAHA ? 217
13*a*. Dorsal view of a cast, with some portions of the posterior margins wanting.
13*b*. Side view of same. (Plattsmouth.)

* This is the shell described by Professor McChesney (Palæozoic Fossils, page 43, 1860) under the name *Spirifer perplexus*; it is always small, and may be distinct from *S. lineatus*. The desiription of it was inadvertently omitted in our text.

† This cast is too imperfect for description or identification. It does not differ, however, so far as can be seen, from a form common in the Coal-Measures of Illinois, but seems to be different from the Nebraska City specimen, referred (erroneously, as I think) by Professor Geinitz to *S. biarmica*, de Verneuil.



EXPLANATIONS OF PLATE III.

Page.

1.—PHILLIPSIA, sp. 237

1*a*. Pygidium one-eighth diameter less than natural size.

1*b*. Same, enlarged. (Both from Geinitz, Plattsmouth.)

2. PHILLIPSIA MAJOR 238

2*a*. Pygidium (cast) one-eighth less than natural size, from Bellevue.

2*b*. An outline profile view of same.

2*c*. Part of the pygidium of a larger individual, from Plattsmouth, slightly reduced in size. [Segments of lateral lobes not oblique enough in the figure.]

3.—PERIPRISTIS SEMICIRCULARIS 242

3*a*. Posterior view of a tooth and root, from Bellevue, showing the profound concavity of the crown, and the serrated edge, slightly less than natural size, with an enlarged outline of the latter above.

4.—PERIPRISTIS SEMICIRCULARIS 242

An internal cast of the deep concavity of the crown (*c*), and a portion of the root (*r*), slightly reduced in size. (Rock Bluff.)

5. PETALODUS DESTUCTOR 241

A specimen consisting of nearly an entire crown, and a portion of the root, posterior view, represented slightly less than natural size. (Rock Bluff.)

6.—CLADODUS MORTIFER 239

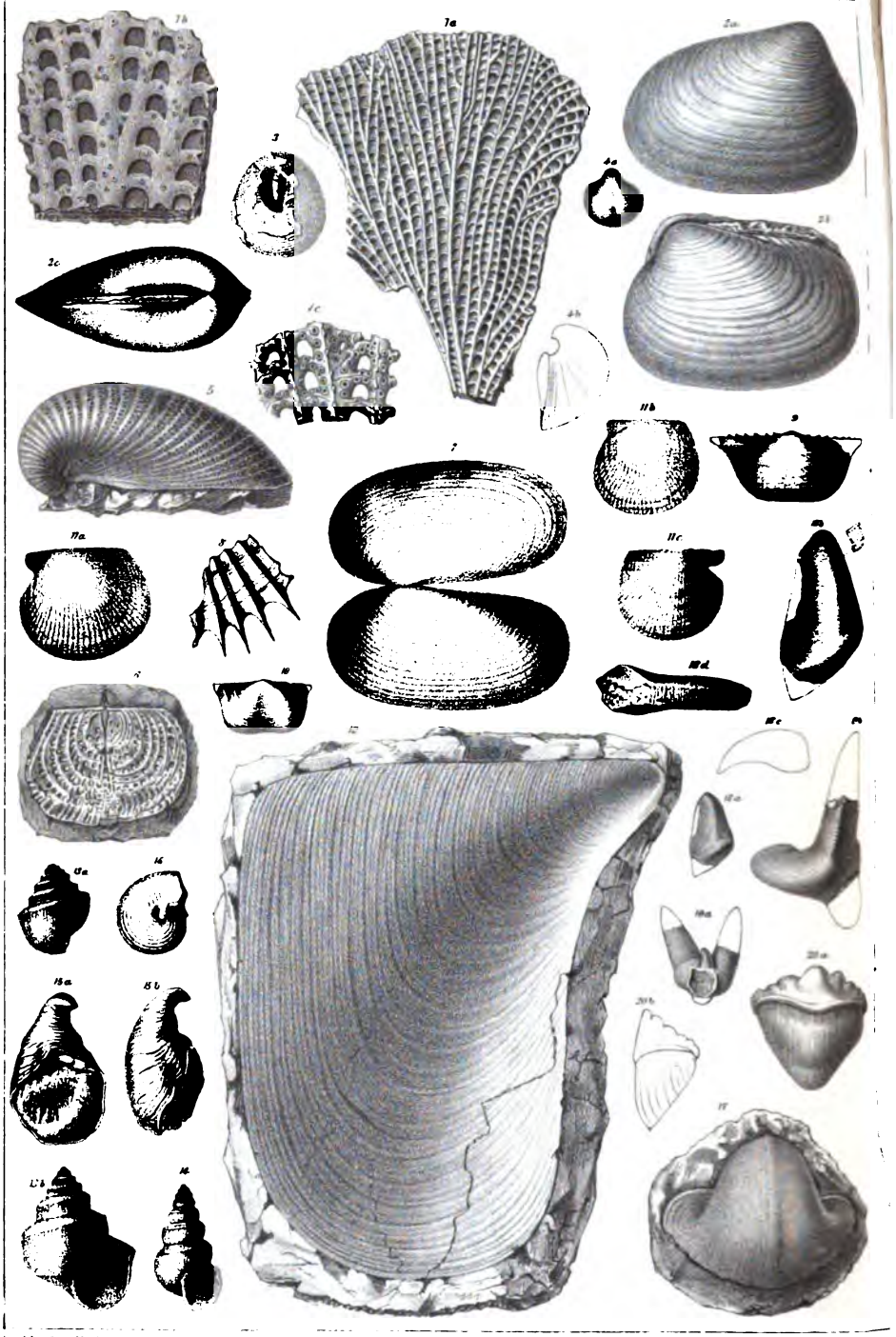
6*a*. A fragment of the main cusp, near base, slightly reduced in size.

6*b*. Outline restoration of the whole tooth.

7.—NAUTILUS PONDEROSUS 236

7*a*. View of the flattened or slightly concave ventral or outer side of a large specimen, reduced to slightly less than two-fifths diam. of natural size.

7*b*. Side view of some. (Plattsmouth.)



EXPLANATIONS OF PLATE IV.*

Page.

Fig. 1.—SYNOCLADIA BISERIALIS 156
1*a*. A portion of the polyzoum, one-eighth diameter less than natural size, non-poriferous side.
1*b*. A portion of same, magnified so as to show the fine striæ, and irregularly scattered dimorphous pores, same side.
1*c*. Poriferous side of a fragment, magnified.

Fig. 2.—EDMONDIA ASPINWALLENSIS 216
2*a*. Side view of internal cast, one-eighth diameter less than natural size.
2*b*. View of the left valve, with the beak and dorsal margin of the right valve seen above, in consequence of a slight displacement.
2*c*. Dorsal view of the cast of both valves united. (Aspinwall.)

Fig. 3.—ORBICULOIDEA, sp 158
An impression of the outside of the under valve in the matrix (slightly less than natural size), with portions of the thin shell adhering, so as to show the smooth inside, and a prominent internal ridge (*d*) corresponding to a deep external furrow, with a small, round, or oval foramen at its outer end.

Fig. 4.—SPIRIFER (MARTINIA) PLANOCONVEXUS 184
4*a*. Ventral view, slightly less than natural size.
4*b*. Outline profile view of same, magnified.

Fig. 5.—PRODUCTUS PUNCTATUS 169
Side view of an accidentally compressed ventral valve, a little reduced in size.

Fig. 6.—PRODUCTUS NEBRASCENSIS 165
An impression in the matrix of the inner side of a ventral valve, one-eighth diameter less than natural size.

Fig. 7.—EDMONDA REFLEXA? 213
A slightly reduced view of the two valves opened and spread out upon the matrix. [This figure does not show the marks of growth strong enough, and has the beaks a little too far forward.]

Fig. 8.—AVICULOPECTEN CARBONIFERUS 193
A fragment of a left valve, enlarged nearly two diameters, and showing the costæ and marginal digitations.

Fig. 9.—CHONETES GRANULIFERA 170
A ventral view, slightly reduced in size.

Fig. 10.—CHONETES GLABRA 171
A ventral view, slightly reduced in size.

Fig. 11.—AVICULOPECTEN? WHITEI 195
11*a*. Left valve, flattened by pressure; one-eighth diameter less than natural size.
11*b*. Another of the same, of smaller size.
11*c*. A flattened right valve, showing the deeper sinus under the anterior ear; slightly reduced in size.

Fig. 12.—MYALINA SUBQUADRATA 202
An impression of the left valve (reduced one-eighth diameter) in the clay matrix, with adhering portions of the thin outer fibrous layer of shell remaining.

Fig. 13.—PLEUROTOMARIA PERHUMEROSA 232
13*a*. A somewhat distorted specimen the distortion making the spire appear rather shorter than natural (a little reduced in size).
13*b*. Another specimen from Rulo, enlarged nearly two diameters, and somewhat restored.

Fig. 14.—PLEUROTOMARIA INORNATA 232
View of side and aperture, slightly reduced in size.

* All the specimens figured on this plate, not otherwise designated, are from a shaft sunk to a depth of about 100 feet, at an elevation of 73 feet above the Missouri, one mile and three-fourths west of Nebraska City landing.

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Fig. 15.—PLATYCERAS NEBRASCENSIS 227
15*a*. View of aperture, and laterally curved apex.
15. A side view, showing the undulated lip and marks of growth.

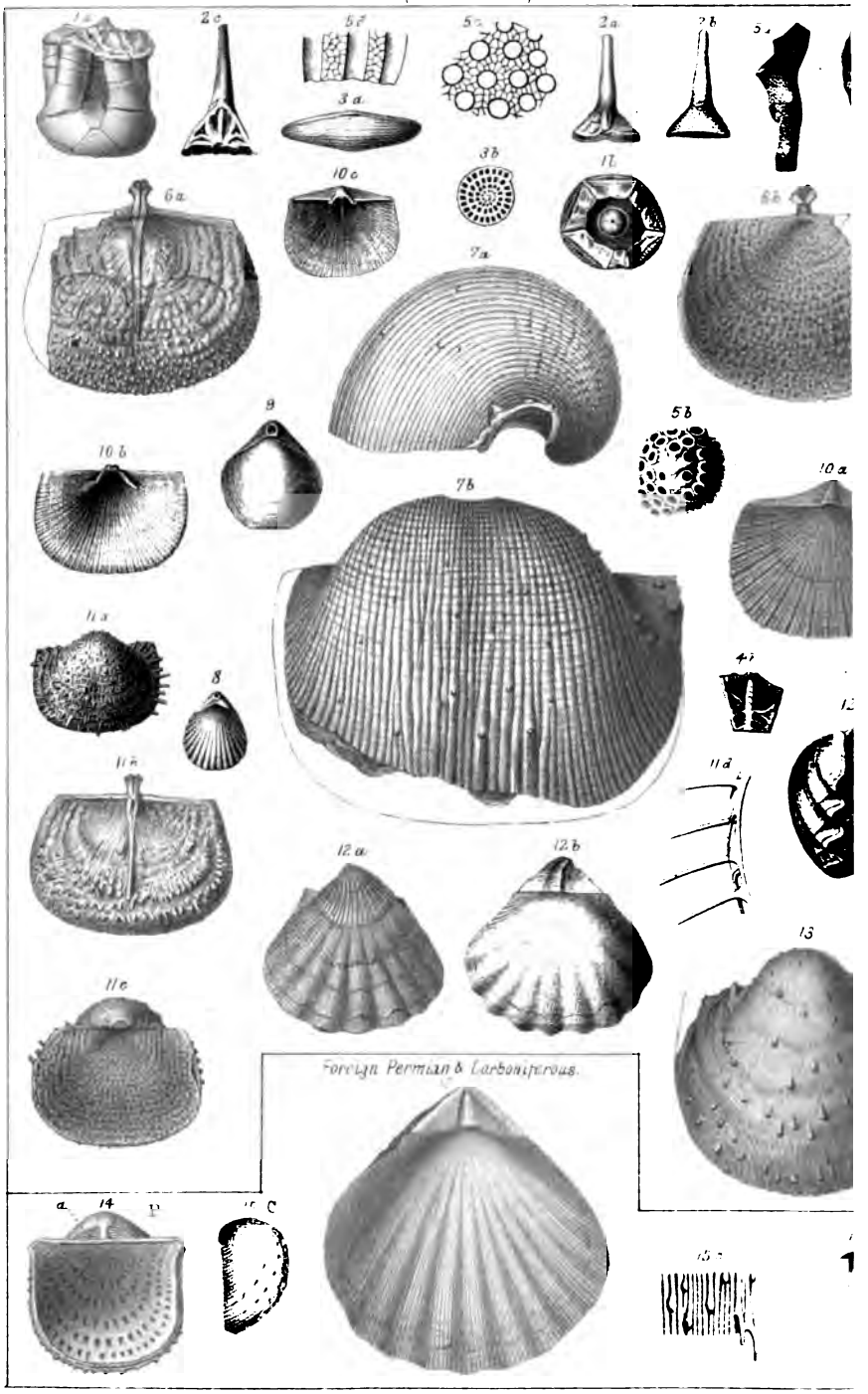
Fig. 16.—BELLEROPHON CARBONARIUS 224
A side view, a little reduced in size, of a specimen from Mr. Morton's shaft.

Fig. 17.—BELLEROPHON MARCOUIANA 226
A cast somewhat flattened and distorted by pressure, with much of the expanded lip also broken away; enlarged nearly two diameters.

Fig. 18.—XYSTRODUS ? OCCIDENTALIS 244
18*a*. Upper view, a little less than natural size.
18*b*. The same, magnified nearly two diameters, and a portion of the pitted surface still further magnified.
18*c*. Outline transverse section across the widest part.
18*d*. Side view of same. (From Aspinwall.)

Fig. 19.—DIPLODUS COMPRESSUS 240
19*a*. Anterior view, a little less than natural size, of a specimen, with the cusps, and anterior tubercle of the root in part broken away.
19*b*. Lateral view of same, magnified.

Fig. 20.—PERIPRISTIS SEMICIRCULARIS 242
20*a*. View of the convex side of the root and crown, slightly less than natural size.
20*b*. An outline lateral view of the same.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EXPLANATIONS OF PLATE V.

Page.

Fig. 1.—SCAPHIOCRINUS? HEMISPHÆRICUS 147

1*a*. Posterior view of body and arm-bases, including a few pieces above the bifurcation on the second primary radial pieces; all reduced one-eighth diameter in size.

1*b*. Another specimen, with the second radials and arms removed, so as to show the upper and inner side of the cup in which the internally protuberant base is seen in the form of a little depressed cone within.

Fig. 2.—ZEACRINUS MUCROSPINUS 149

2*a* & *b*. Two views of the spine-like second radial pieces, reduced one-eighth diameter, from Professor Geinitz's figures.

2*b*. Upper side of the same, reduced from Professor McChesney's figures of an unworn specimen.

Fig. 3.—FUSULINA CYLINDRICA 140

3*a*. A specimen magnified nearly three diameters.

3*b*. A transverse section of the same, somewhat more enlarged, to show the involuted and septate character of the interior.

Fig. 4.—LOPHOPHYLLUM PROLIFERUM 144

4*a*. A side view, slightly less than natural size, of a specimen with the walls of the cup partly broken away, so as to show the end of the columella within.

4*b*. A longitudinal section of another specimen of the same species, slightly reduced in size, showing the transverse arching plates, columella, &c.

Fig. 5.—FISTULIPORA NODULIFERA 143

5*a*. A specimen nearly natural size, incrusting a piece of another little coral of ramose form.

5*b*. One of the nodes or prominences of the same, enlarged so as to show the pores with their prominent margins, all directed a little outward from the middle of the prominence, which is nearly without pores.

5*c*. A transverse section of a portion of the same species, more highly magnified, to show the finely cellular tissue between the cell-tubes.

5*d*. A magnified longitudinal section of a piece of the same species, cutting through the cell-tubes and exposing the intercellular tissue.

Fig. 6.—PRODUCTUS SYMMETRICUS 167

6*a* & *b*. Slightly reduced interior and exterior views of a dorsal valve, with the trifid cardinal process, which does not show its entire length, owing to its strong curve. In Fig. 6*a*, the reniform scars are put in from another specimen of the same species, not being defined in that figured.

Fig. 7.—PRODUCTUS SEMIRETICULATUS 160

7*a*. Side view (slightly reduced in size) of a specimen with the anterior margin not quite complete.

7*b*. Ventral view of another somewhat larger specimen, also reduced a little in size.

Fig. 8.—RETZIA PUNCTULIFERA 181

Dorsal view of a small specimen, enlarged to nearly two diameters.

Fig. 9.—ATHYRIS SUBTILITA 180

Dorsal view of a medium-sized specimen, slightly reduced in size.

Fig. 10.—HEMIPRONITES CRASSUS 174

10*a*. Dorsal view of a medium-sized specimen (slightly reduced in size), showing the area of the ventral valve with its false deltidium.

10*b*. Interior of a smaller ventral valve, showing the cardinal process (also slightly reduced).

Fig. 11.—PRODUCTUS NEBRASCENCIS 165

11*a*. Ventral view of *a small specimen* (reduced one-eighth diameter *in size), showing spine bases.*

Page.

FIG. 11.—11*b*. Interior of a larger dorsal valve, also reduced in size, showing the bifid cardinal process, and the divided mesial ridge, internal asperities, &c.

11*c*. Dorsal view of another specimen (slightly reduced in size), showing the cardinal margin without traces of an area, and the slightly truncated beak of the ventral valve.

11*d*. A diagram profile view, enlarged, of a piece of the shell of the ventral valve, to show the two sets of spines.

Fig. 12.—MEEKELLA STRIATO-COSTATA 175

12*a*. Ventral view of a rather small specimen, enlarged to nearly the medium adult size of the species.

12*b*. Dorsal view of same, showing area and false deltidium.

Fig. 13.—PRODUCTUS PRATTENIANUS 163

A view of the ventral side of a moderately large specimen, slightly reduced in size, from Professor Geinitz's figure, with the ears and spines broken away. (The restored outline of the ears has been added from our specimens.)

FOREIGN SPECIES FOR COMPARISON.

Fig. 14.—STROPHALOSIA HORRESCENS 167

Dorsal view, showing hinge line and cardinal area (*a*), for comparison with Fig. 11*c*. (Slightly reduced in size, from Professor Geinitz's Animalischen Ueberr. der Dyas.)

Fig. 15.—PRODUCTUS KONINCKIANUS 164

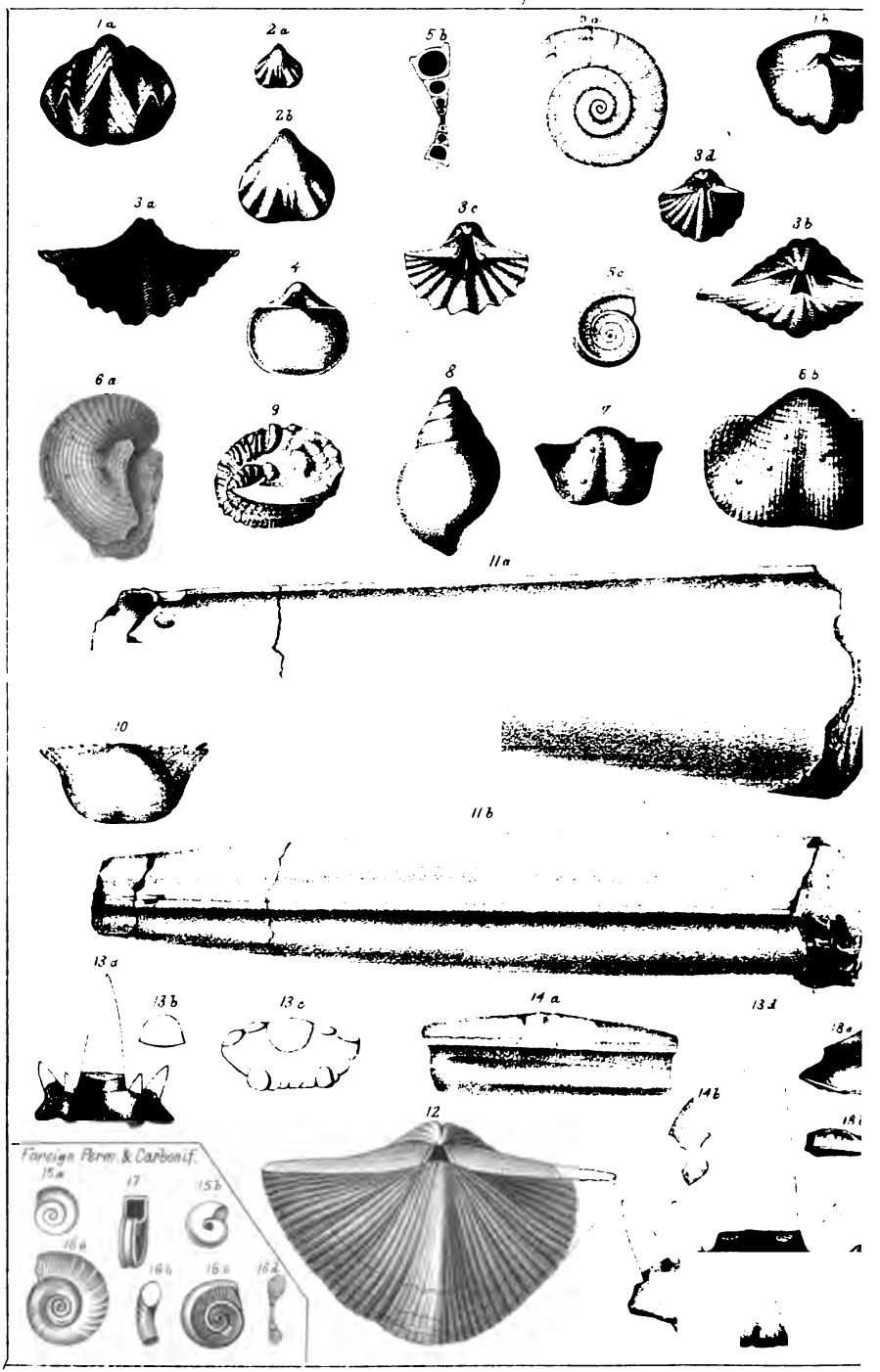
15*a*. Side view, slightly reduced in size.

15*b*. Ventral view of same, slightly reduced in size.

15*c*. An enlargement of a piece of the surface, showing the striæ and short spines magnified. All after Mr. Davidson. For comparison with Fig. 13.

Fig. 16.—MEEKELLA PECTINIFORMIS, (=*Streptorhynchus pectiniformis*) 175

Dorsal view, showing area and deltidium of ventral valve (a little reduced in size, from Mr. Davidson). For comparison with Fig. 12*b*.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EXPLANATIONS OF PLATE VI.

Page.

Fig. 1.—SYNTRILASMA HEMIPLICATA 177
1*a*. Front view, a little reduced in size.
1*b*. Cardinal or posterior view of same.

Fig. 2.—RHYNCHONELLA OSAGENSIS 179
2*a*. Ventral view, reduced one-eighth diameter in size.
2*b*. Same, enlarged nearly two diameters of natural size.

Fig. 3.—SPIRIFERINA KENTUCKENSIS 185
3*a*. A specimen greatly extended on the hinge line; enlarged nearly to two diameters.
3*b*. Cardinal or posterior view of same.
3*c*. Cardinal and internal view of another specimen of ventral valve enlarged, showing internal lamina.
3*d*. A very small individual, with hinge line short; magnified two diameters.

Fig. 4.—SPIRIFER (MARTINIA) PLANOCONVEXUS 184
Dorsal view, magnified nearly two diameters.

Fig. 5.—EUOMPHALUS RUGOSUS, (Hall; not Sowerby) 230
5*a*. Left view, magnified nearly two diameters.
5*b*. Section of same, showing the quadrangular form of the volutions, and the concavity of the right side.
5*c*. Right or concave side of another specimen, one-eighth diameter less than natural size.

Fig. 6.—PRODUCTUS COSTATUS ? 159
6*a*. Profile side view, reduced one-eighth diameter in size.
6*b*. Ventral view, same.

Fig. 7.—PRODUCTUS LONGISPINUS ?..... 161
Ventral view, reduced one-eighth diameter in size.

Fig. 8.—MACROCHEILUS INTERCALARIS, *Var.* PULCHELLUS..... 228
A side view, reduced one-eighth diameter in size.

Fig. 9.—PHILLIPSIA SCITULA 238
A crushed specimen, enlarged about two diameters.

Fig. 10.—CHONETES GRANULIFERA 170
A ventral view, slightly reduced in size.

Fig. 11.—PINNA PERACUTA 198
11*a*. Side view (slightly reduced in size) of an internal cast, incomplete at both ends.
11*b*. Dorsal view of same.

Fig. 12.—SPIRIFER CAMERATUS..... 183
A dorsal view, nearly natural size, showing area and foramen.

Fig. 13.—CLADODUS MORTIFER 239
13*a*. A specimen, consisting of the root of a tooth, with the bases of the cusps remaining; one-eighth diameter less than natural size.
13*b*. An outline section of the main cusp, at base.
13*c*. An outline view from above.
13*d*. An opposite view of the root and bases of cusps, enlarged.

Fig. 14.—CHOMATODUS ARCUATUS 243
14*a*. View of anterior side, one-eighth diameter less than natural size.
14*b*. Profile or section of the same.

Fig. 18.—DELTODUS ? ANGULARIS 244
18*a*. View of upper surface, somewhat reduced in size.
18*b*. Profile view of same.

FOREIGN SPECIES FOR COMPARISON.

Fig. 15.—SPIRORBIS PERMIANUS 231
15*a*. View of left or attached side, magnified nearly three times, for comparison with 5*a* and 16*a*.
15*b*. Right or free side of same, for comparison with 5*c* and 16*c*: after Professor King.

Page.

Fig. 16.—SPIRORBIS PLANORBITES 220

16*a*. Left view, magnified nearly three diameters, for comparison with Fig. 5*a*.

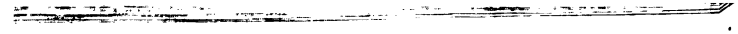
16*b*. A fragment of the same, showing a section of whorls, for comparison with 5*b*.

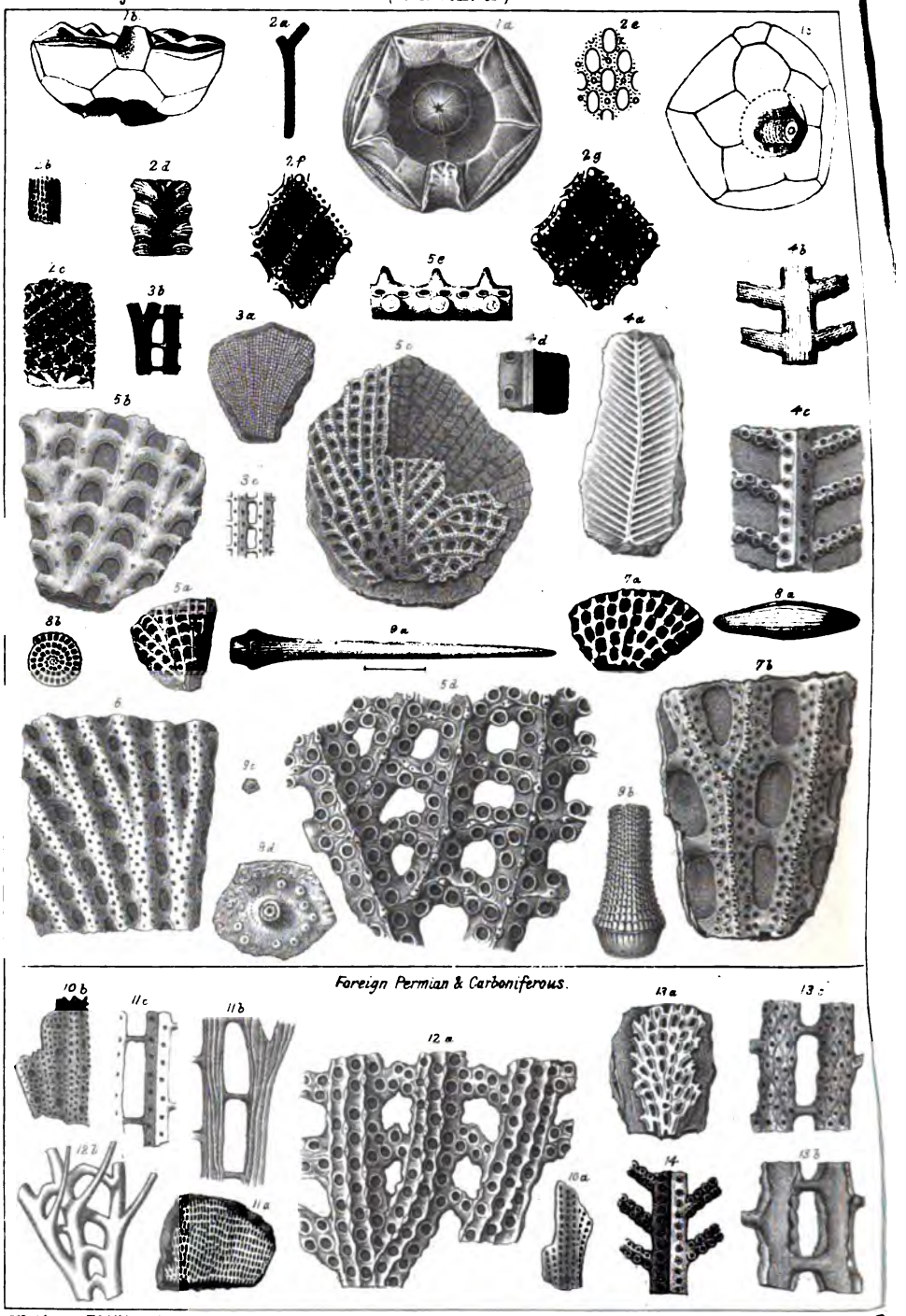
16*c*. Another specimen of same, magnified two diameters, right side for comparison with 5*c*.

16*d*. Section of last, for comparison with 5*b*: all after Professor Geinitz.

Fig. 17.—EUOMPHALUS QUADRATUS 231

An oblique anterior view. (Slightly reduced from Professor McCoy's figure.

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EXPLANATIONS OF PLATE VII.

Page.

Fig. 1.—SCAPHIOCRINUS? HEMISPHÆRICUS 147

1*a*. View of the body from above, slightly reduced.

1*b*. View of the same from below.

1*c*. Posterior side of same in outline; all slightly reduced from Professor Geinitz's figures.

Fig. 2.—RHOMBOPORA LEPIDODENDROIDES 141

2*a*. Branch, one-eighth diameter less than natural size.

2*b*. Part of same, magnified a little less than three diameters.

2*c*. Same, magnified about six diameters, to show the angular outlines of the calices, and the granules at their angles and along their margins.

2*d*. Longitudinal section, magnified nearly five diameters, showing the calices (c) *apparently* without tabulæ or septa, ascending from an imaginary axis, and the interspaces (i), with longitudinal sections of very minute intermediate pores.

2*e*. Portion of surface, ground off a little obliquely, showing the calices within rather more oval in outline than natural, with the very minute pores of the interspaces, apparently corresponding to the marginal granules of the exterior.

2*f*. Four of the calices, greatly magnified, to show their rhombic outline and marginal granules.

2*g*. Same, from another part of the same species, where they differ a little in form.

Fig. 3.—FENESTELLA SHUMARDI? 153

3*a*. Fragment of the polyzoum slightly less than natural size, non-poriferous side.

3*b*. Fragment of the same, magnified to show the form and proportions of the fenestrules, branches, and dissepiments, comparatively course striæ, &c.

3*c*. Same, poriferous sides.

Fig. 4.—GLAUCONOME TRILINEATA, Meek 157

4*a*. Slightly less than natural size, non-poriferous side.

4*b*. Same, enlarged to show striæ.

4*c*. Poriferous side enlarged.

4*d*. Fragment of main stem, greatly magnified, to show the three mesial lines.

Fig. 5.—SYNOCLADIA BISERIALIS, (=*S. Cestriensi*?) 156

5*a*. Fragment, slightly less than natural size, non-poriferous side.

5*b*. Same, magnified about five diameters, to show striæ and dimorphous pores.

5*c*. Poriferous side of another specimen, a little enlarged.

5*d*. Part of same, greatly magnified, to show the arrangement of the pores, the mesial carina, and spine-like projections, with their minute perforations, &c.

5*e*. Side view of one of the branches, much enlarged, to show the elevation of the spine-like projections along the middle, on the poriferous side.

Fig. 6.—POLYPORA 155

Enlarged poriferous side, slightly reduced from Professor Geinitz's figure.

Fig. 7.—POLYPORA SUBMARGINATA 154

7*a*. Fragment showing non-poriferous side, slightly less than natural size.

7*b*. Part of same, magnified, showing the poriferous side, with its mesial carina and row of node-like granules.

Fig. 8.—FUSULINA CYLINDRICA 140

8*a*. Specimen magnified a little more than three diameters.

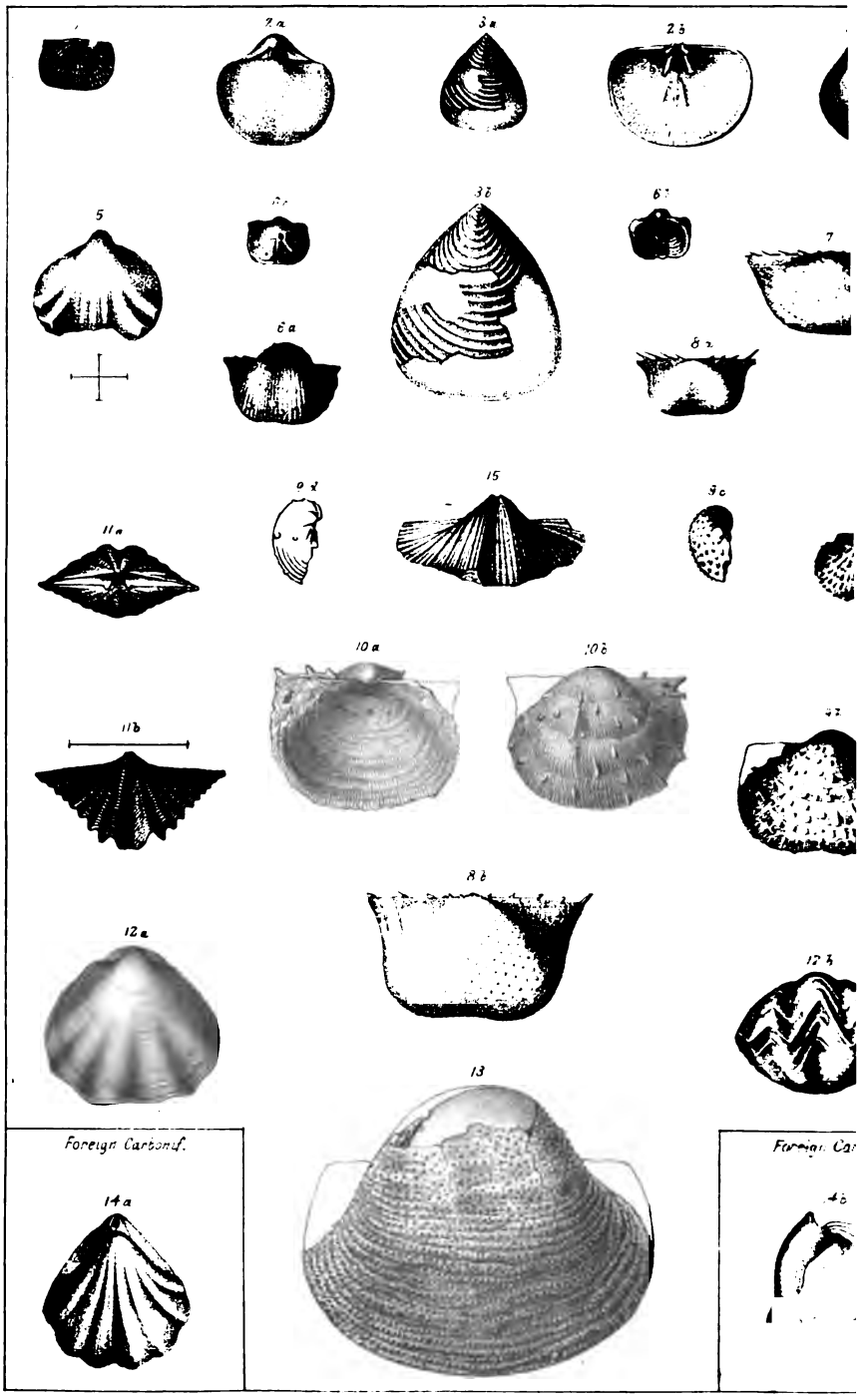
8*b*. Transverse section of the same, magnified between four and five diameters, so as to show the internal structure.

Page.

Fig. 9.—EOCIDARIS HALLIANA 152
9*a*. One of the primary spines, magnified a little less than six times.
9*b*. Part of same, still more greatly magnified, to show the surface sculpturing.
9*c*. One of the interambulacral plates of nearly natural size.
9*d*. Same, magnified; (all after Geinitz).

FOREIGN SPECIES FOR COMPARISON.

Fig. 10.—POLYPOR BIARMICA 155
10*a*. A piece of the polyzonm, slightly less than natural size.
10*b*. Magnified portion of same, to compare with Fig. 6. Both from Count Keyserling's illustrations of the species.
Fig. 11.—FENESTELLA PLEBEJA 153
11*a*. Fragment, nearly natural size, to compare with Fig. 3*a*.
11*b*. A piece of the same, non-poriferous side, greatly enlarged, to compare with Fig. 3*b*.
11*c*. Another fragment, greatly enlarged, showing poriferous side, for comparison with Fig. 3*c*. (All from McCoy's figures of the typical specimens.)
Fig. 12.—SYNOCLADIA VIRGULACEA 156
12*a*. Fragment, greatly enlarged, showing the poriferous side, for comparison with Fig. 5*d*.
12*b*. Non-poriferous side, magnified to show spine-like processes, for comparison with Fig. 5*b*. (All from Professor King's figures.)
Fig. 13.—POLYPORA MARGINATA 154
13*a*. Fragment, slightly less than natural size, nonporiferous side, for comparison with Fig. 7*a*.
13*b*. Piece of same, magnified, to show surface striæ of non-poriferous side, &c.
13*c*. Poriferous side of same, magnified, to compare with Fig. 7*b*. (All from Professor McCoy's original figures.)
Fig. 14.—GLAUCONOME GRANDIS 157
14. Fragment, greatly enlarged, showing poriferous side, for comparison with Fig. 4*c*. (From Professor McCoy's figure.)



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EXPLANATIONS OF PLATE VIII.

Page.

Fig. 1.—HEMIPRONITES CRASSUS 174
A very small young specimen.

Fig. 2.—SPIRIFER (MARTINIA) PLANOCONVEXUS 184
2*a*. Dorsal view, showing area and foramen of ventral valve magnified to nearly two diameters.
2*b*. Interior of dorsal valve, showing socket processes and crura for the attachment of the spires, still more enlarged.

Fig. 3.—LINGULA SCOTICA, *var.* NEBRASCENSIS 158
3*a*. View of dorsal valve, slightly less than natural size.
3*b*. Enlargement of same.

Fig. 4.—ATHYRIS SUBTILITA 180
Small specimen, dorsal view; slightly reduced in size from Professor Geinitz's figure of a specimen from bed C, at Nebraska City.

Fig. 5.—RHYNCHONELLA OSAGENSIS 179
Ventral view (enlarged nearly two and one-half diameters); after Professor Geinitz's figure of a rather broad, flattened specimen from bed C, at Nebraska City.

Fig. 6.—PRODUCTUS LONGISPINUS? 161
6*a*. Ventral view, slightly less than natural size.
6*b* & *c*. Dorsal and ventral views of a young example; after Geinitz.

Fig. 7.—CHONETES GRANULIFERA 170
Ventral view, nearly natural size, showing a few very scattering large perforations.

Fig. 8.—CHONETES GLABRA 171
8*a*. Ventral view, nearly natural size.
8*b*. Ditto of another specimen, enlarged nearly to two diameters, to show what appears to be the bases of minute, scattering spines, connected with large, distantly-separated perforations, arranged in quincux.

Fig. 9.—PRODUCTUS PERTENUIS 164
9*a*, *c*. Ventral and lateral views of an imperfect specimen, nearly natural size.
9*b*. The same enlarged. Both figured by Professor Geinitz, from bed C, Nebraska City.

Fig. 10.—PRODUCTUS PRATTENIANUS 163
10*a* & *b*. Dorsal and ventral views of a young shell; specimen nearly natural size; figured by Professor Geinitz, from bed C, at Nebraska City.

Fig. 11.—SPIRIFERINA KENTUCKENSIS 185
11*a*. Posterior or cardinal view, showing area and foramen, beaks, &c. (Enlarged about one and one-half diameters).
11*b*. Ventral view of a compressed specimen, enlarged nearly two diameters. Both from Professor Geinitz's figures of specimens from bed C, Nebraska City.

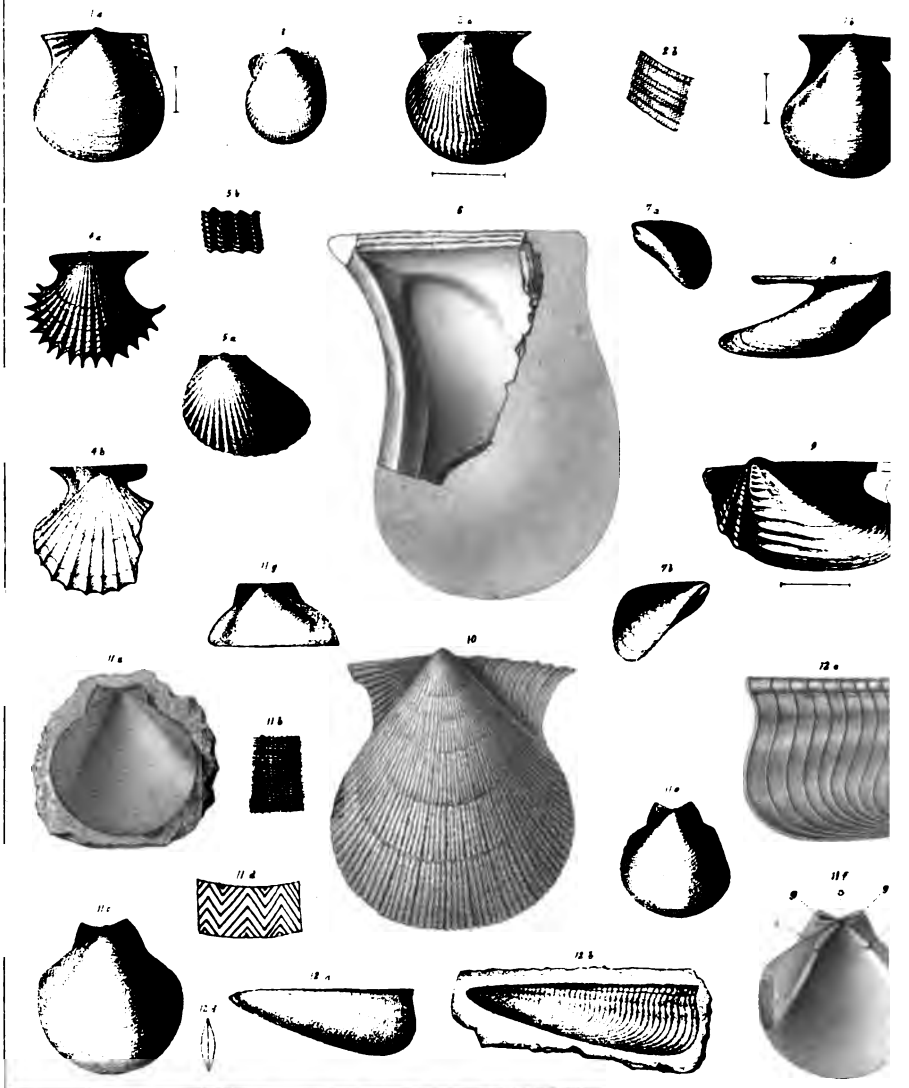
Fig. 12.—SYNTRILASMA HEMIPLICATA 177
12*a* & *b*. Ventral and front views; slightly reduced from Professor Geinitz's figures of a Nebraska City specimen.

Fig. 13.—PRODUCTUS SYMMETRICUS 167
Ventral view of an imperfect specimen from bed C, Nebraska City, slightly less than natural size.

FOREIGN SPECIES FOR COMPARISON.

Fig. 14.—RHYNCHONELLA ANGULATA 178
14*a*, *b*. Dorsal and side views for comparison with Fig. 12*a*, *b*; both slightly reduced from Mr. Davidson's figures.

Fig. 15.—SPIRIFER CAMERATUS 183
An imperfect, rather small, specimen, from bed C, Nebraska City.



Foreign Carboniferous, Permian & Jurassic.

EXPLANATIONS OF PLATE IX.

Page.

Fig. 1.—AVICULOPECTEN NEGLECTUS 193
1*a*. Internal cast of a left valve, enlarged nearly to three and one-half diameters. (From Geinitz.)
1*b*. Ditto of a right valve, from bed C, at Nebraska City, enlarged nearly three and one-half diameters.

Fig. 2.—AVICULOPECTEN COXANUS 196
2*a*. Left valve enlarged about two diameters.
2*b*. Enlargement of surface markings of same.

Fig. 3.—PSEUDOMONOTUS RADIALIS ?? 201
View of cast of left valve, slightly less than natural size.

Fig. 4—AVICULOPECTEN CARBONIFERUS 193
4*a*. Left valve, one-eighth diameter less than natural size.
4*b*. Internal cast of a right valve a little less than two diameters.

Fig. 5.—LIMA RETIFERA 188
5*a*. Cast of right valve, one-eighth diameter less than natural size.
5*b*. Costæ of same, a little enlarged.

Fig. 6.—MYALINA SUBQUADRATA 202
A fragment of a right valve, showing cardinal area, and interior, nearly natural size, from Professor Geinitz's figure of a specimen from bed C, at Nebraska City. The dimly-shaded outline is here added to show the most usual form of the entire shell.

Fig. 7.—MYALINA SWALLOVI 201
7*a*. Left view of a small specimen, slightly less than natural size.
7*b*. Right view of a larger individual, slightly reduced in size.

Fig. 8.—AVICULA LONGA 199
Right valve, enlarged nearly two diameters.

Fig. 9.—AVICULA ? SULCATA 200
Left valve enlarged to nearly three and a half diameters; from Professor Geinitz's figure.

Fig. 10.—AVICULOPECTEN OCCIDENTALIS 191
Left valve slightly reduced in size; from Professor Geinitz's figure.

Fig. 11.—ENTOLIUM AVICULATUM 189
11*a*. Mould of the exterior (nearly natural size) of left valve.
11*b*. Enlarged external radiating and concentric striæ.
11c. Cast from the same.
11*d*. Enlarged zigzag marking sometimes very dimly seen on the surface of internal casts.
11*e*. Cast of a smaller specimen, left valve, with posterior margin a little truncated.
11*f*. Interior of another specimen, left valve, showing the diverging hinge, teeth (t, t), cartilage pit (c), and transverse furrow (g, g), in the ears, for the articulation of the margin of the other valve.
11*g*. Cast of the interior of opposite valve, showing its cardinal line to be straight, apparently for articulation in the furrow (g) of Fig. 11*f*.

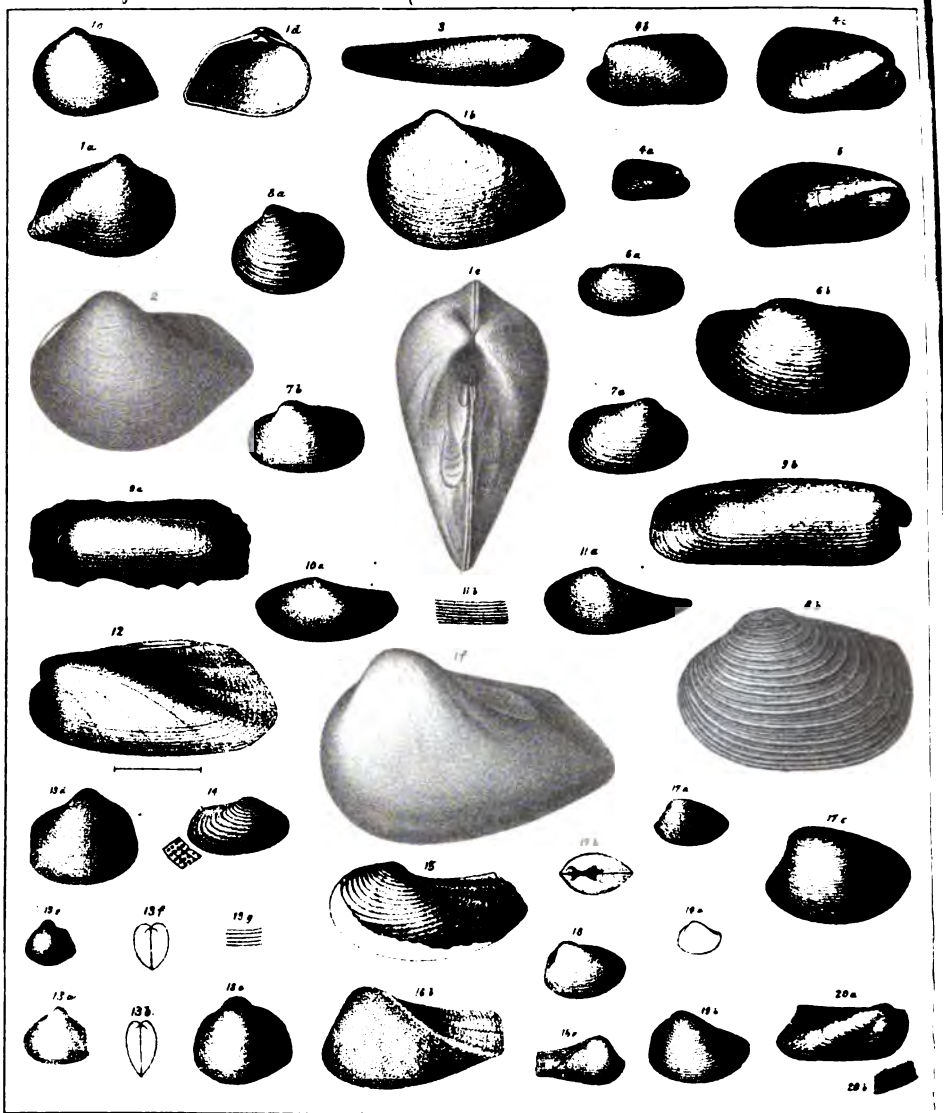
Fig. 12.—AVICULOPINNA AMERICANA 197
12*a*. An internal cast, enlarged to nearly two diameters, showing the beaks not to be quite terminal.
12*b*. Mould of the outside of another specimen, somewhat enlarged.
12*c*. Surface markings, enlarged.
12*d*. Section to show convexity of valves.

FOREIGN SPECIES FOR COMPARISON.

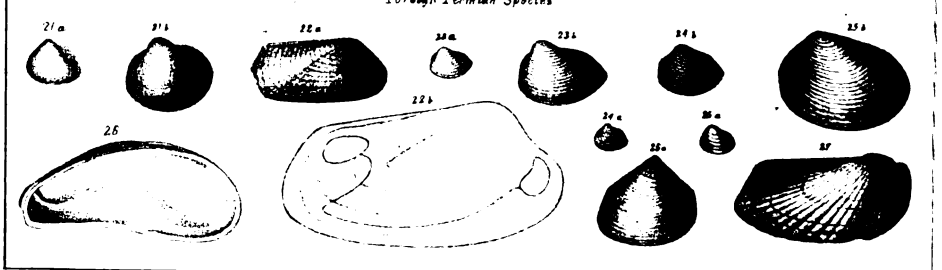
Fig. 13.—ENTOLIUM SOWERBYI 191
13*a*. External view, for comparison with figure 11c.
13*b*. Enlarged surface striæ of same. Both a little less than natural size, from Professor McCoy's Carb. Fossils of Ireland.

Fig. 14.—ENTOLIUM DEMISSUM 190
Internal cast of hinge, for comparison with figure 11*f*; slightly reduced in size; from Quenstedt.

Fig. 15.—AVICULOPINNA PINNÆFORMIS 197
15*a*. View of left valve, showing traces of radiating striæ; a little reduced from Professor Geinitz's figure of a German specimen.
15*b*. *Section of the two valves united, taken from a fragment sent from Germany by Professor* Geinitz to Professor Worthen. *For comparison with Fig. 12.*



Foreign Permian Species.



EXPLANATIONS OF PLATE X.

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Fig. 1.—SCHIZODUS WHEELERI 209
1*a*. Outside view of right valve, slightly reduced from Professor Geinitz's figure; referred by him to *S. obscurus*.
1*b*. Sketch of the typical specimen of S. Wheeleri from the Coal-Measures of Missouri, slightly reduced in size from a drawing in the possession of Professor Swallow.
1*c*. Outside view of a specimen from the Upper Coal-Measures of Iowa, belonging to Dr. C. A. White.
1*d*. Inside of same, showing the hinge; both figures being slightly reduced in size.
1*e* & *f*. Dorsal and lateral views of a large internal cast, a little reduced in size, from the same position in Iowa, and apparently of the same, or a nearly allied species, belonging to Dr. C. A. White.

Fig. 2.—An external cast of an undetermined species of *Schizodus* 210

Fig. 3.—SOLENOPSIS SOLENOIDES 223
Cast of right valve, magnified nearly to two diameters.

Fig. 4.—PLEUROPHORUS OBLONGUS 212
4*a*. Internal cast, about natural size.
4*b* & *c*. Internal casts of other specimens, right and left view, magnified nearly two diameters.

Fig. 5.—MODIOLA? SUBELLIPTICA 211
Right valve, a little less than natural size.

Fig. 6.—EDMONDIA REFLEXA 213
6*a*. An internal cast of a small specimen, one-eighth diameter less than natural size.
6*b*. The same, enlarged.

Fig. 7.—EDMONDIA? GLABRA 214
7*a* & *b*. Right and left views of two small specimens, slightly reduced in size.

Fig. 8.—EDMONDIA NEBRASCENSIS? 214
8*a*. A slightly reduced figure of a small, rather broad, specimen, probably of this species.
8*b*. The larger and more elongated typical form of the species, a little reduced in size.

Fig. 9.—PROTHYRIS ELEGANS 223
9*a*. Left valve of nearly natural size, showing anterior ventral notch, and linear ridge extending to its corner from the beak.
9*b*. Right valve of another specimen, enlarged to nearly one and a half diameters.

Fig. 10.—YOLDIA SUBSCITULA? 205
An external cast of the left valve, nearly natural size.

Fig. 11.—NUCULANA BELLISTRIATA 206
11*a*. Left valve, enlarged to nearly two diameters.
11*b*. Surface striæ, further enlarged.

Fig. 12.—PLEUROPHORUS OCCIDENTALIS 212
Left view of internal cast, enlarged to nearly three diameters. (From Professor Geinitz.)

Fig. 13.—SCHIZODUS CURTUS 208
13*a*. Cast from Nebraska City, left view, one-eighth diameter less than natural size.
13*b*. Outline profile, anterior view of same.
13*c*. A somewhat larger specimen of same, a little reduced in size.
13*d*. A still larger specimen, of somewhat different form, a little reduced in size. Probably a different species.
13*e*. The typical form of *S. curtus*, slightly reduced in size, from the original locality in Illinois.
13*f*. An outline anterior view of same, to show its convexity.
13*g*. Surface striæ of same, enlarged.

Fig. 14.—ALLORISMA SUBELEGANS 220
A little less than natural size, with enlargement of surface granules.

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Fig. 15.—ALLORISMA (SEDGWICKIA) REFLEXA 217
An imperfect left valve, nearly natural size.

Fig. 16.—ALLORISMA (SEDGWICKIA) GEINITZII 219
16*a*. View of right valve, slightly less than the natural size, of one of the largest specimens among an extensive collection.
16*b*. Left valve of another individual, enlarged a little less than two diameters, to show the fine surface granules.

Fig. 17.—NUCULA VENTRICOSA 204
17*a*. Left view, a little less than natural size.
17*b*. Dorsal outline view of same.
17*c*. Left view of same, enlarged to nearly two diameters.

Fig. 18.—NUCULA BEYRICHII ?? 203
An internal cast, enlarged to nearly three diameters. From Nebraska City.

Fig. 19*a*.—An outline, nearly natural size, of a different form, from Professor Geinitz's figure, referred by him to *N. Beyrichi*, from the same bed as the last, at Nebraska City.
19*b*. The same, enlarged to show the striæ; (from Geinitz.)

Fig. 20.—MACRODON TENUISTRIATA 207
20*a*. Right valve, nearly natural size.
20*b*. Enlargement of the minute radiating striæ on the anterior part of the shell.

FOREIGN SPECIES FOR COMPARISON.

Fig. 21.—SCHIZODUS ROSSICUS 209
21*a*. Left view, slightly less than natural size, for comparison with Fig. 13*a*.
21*b*. A different form, supposed to be a variety of the same; both from de Verneuil.

Fig. 22.—ALLORISMA ELAGANS 219
22*a*. Right valve, nearly natural size (from Professor Geinitz), of a German specimen, for comparison with Fig. 16*a*, *b*.
22*b*. Internal cast of same, slightly reduced in size, from Professor King. Compare with Fig. 16*a*, *b*.

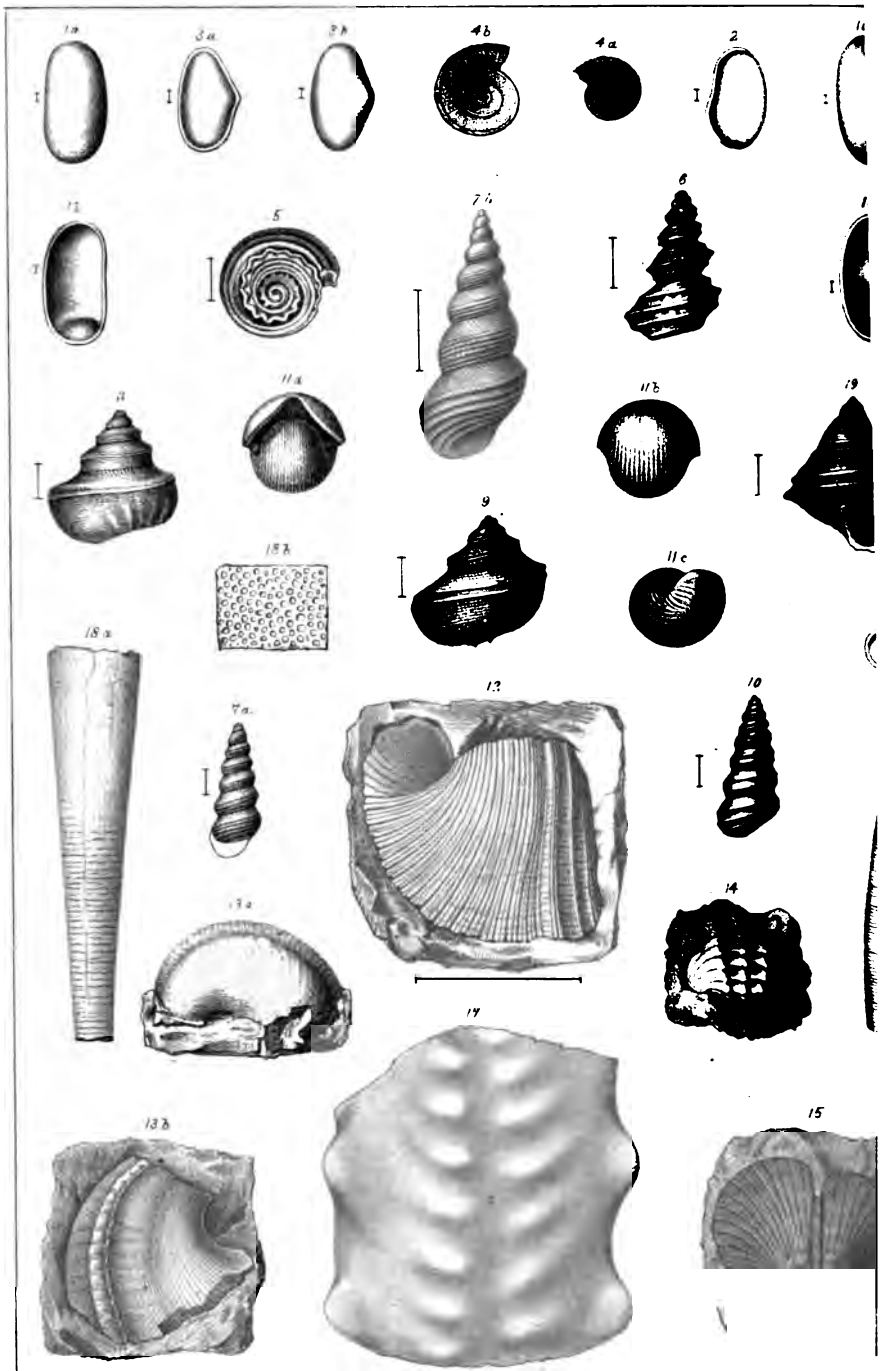
Fig. 23.—NUCULA BEYRICHII 204
23*a*. From a German specimen, slightly less than natural size. Compare with Figs. 18 and 19.
23*b*. Same, enlarged.

Fig. 24.—NUCULA BEYRICHII 204
24*a*, *b*. After Geinitz, from German specimen, nearly natural size, and enlarged. Compare with Figs. 18 and 19.

Fig. 25.—NUCULA BEYRICHII 204
25*a*. Nearly natural size, from von Schauroth's original figure.
25*b*. Same, from same, enlarged. Compare with Figs. 18 and 19.
25*c*. Internal cast of same, from same.

Fig. 26. CARDIOMORPHA ? (MYTILUS) PALLASI 212, 213
Hinge and interior of right valve, nearly natural size. For comparison with Fig. 12.

Fig. 27. MACRODON STRIATA 207
Right view, after Professor Geinitz, from German specimen, for comparison with Fig. 20*a*.


1a
3a
3b
4b
4a
2
1
12
5
7a
6
11a
11b
9
11c
18a
18b
7a
13
10
13a
14
17
15
13b

EXPLANATIONS OF PLATE XI.

Page.

Fig. 1.—CYTHERE, sp. 237
1*a*, *b*. Outside and inside view of right valve, greatly enlarged.
1c, *d*. Outside and inside of left valve, greatly enlarged.

Fig. 2.—CYTHERE NEBRASCENSIS 237
Inside, greatly enlarged, left valve; from Geinitz.

Fig. 3.—CYTHERE, sp. 237
3*a*, *b*. Outside and inside of apparently the right valve of the same species; from Geinitz.

Fig. 4.—EUOMPHALUS RUGOSUS, (Hall; not Sowerby) 230
4*a*. Left side of a rather small specimen, natural size.
4*b*. Right side of another specimen, somewhat enlarged.

Fig. 5.—PLEUROTOMARIA HAYDENIANA 231
Enlarged nearly to three diameters; from Professor Geinitz's figure.

Fig. 6.—MURCHISONIA NEBRASCENSIS 234
Enlarged less than three diameters; from same.

Fig. 7. ACLIS? SWALLOVIANA 229
7*a*. A very small imperfect specimen, enlarged less than five diameters.
7*b*. A large perfect specimen, enlarged less than three and a half diameters (after Professor Geinitz).

Fig. 8.—PLEUROTOMARIA MARCOUIANA 233
Enlarged less than four diameters; from same.

Fig. 9.—PLEUROTOMARIA GRAYVILLENSIS 233
Enlarged between three and three and half diameters; from same.

Fig. 10.—ORTHONEMA SUBTÆNIATA 228
Enlarged between five and five and a half diameters; from same.

Fig. 11.—BELLEROPHON CARBONARIA 224
11*a*. Front view, nearly natural size.
11*b* & *c*. Posterior and lateral views of same; from division C, at Nebraska City.

Fig. 12.—BELLEROPHON, sp 225
The expanded part of body whorl enlarged about two diameters.

Fig. 13.—BELLEROPHON MARCOUIANUS 226
13*a*. Side view of an imperfect specimen, consisting of a portion of the expanded body volution, enlarged a little less than two diameters.
13*b*. An oblique view of a similar specimen, a little more enlarged; from Professor Geinitz.

Fig. 14.—BELLEROPHON PERCARINATUS 227
A portion of the body volution, slightly less than the natural size.

Fig. 15.—BELLEROPHON MONTFORTIANUS 225
Body volution and expanded lip nearly entire, slightly less than the natural size.

Fig. 16.—DENTALIUM MEEKIANUM 224
16*a*. Side view, enlarged between two and three diameters.
16*b*. Enlarged section or aperture of same; both from Professor Geinitz.

Fig. 17.—NAUTILUS OCCIDENTALUS 234
A fragment, showing the outer or ventral side, with the two rows of large lateral nodes, and two rows of smaller alternating mesial nodes; nearly natural size.

Fig. 18.—ORTHOCERAS CRIBROSUM 234
18*a*. Slightly reduced from Professor Geinitz's enlarged figure.
18*b*. Pitted surface of same, enlarged.

Fig. 19.—PLEUROTOMARIA SUBDECUSSATA 233
A side and aperture view, enlarged about four diameters; after same.

CONGRESS, 2 Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. No. 20.

ANNUAL REPORT

OF

HE BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION,

SHOWING

OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION FOR THE YEAR 1870.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1871.

CONGRESS OF THE UNITED STATES, IN THE HOUSE OF REPRESENTATIVES,
FORTY-SECOND CONGRESS, FIRST SESSION, *April* 19, 1871.

The following resolution, originating in the House of Representatives this day, has been concurred in by the Senate, viz:

"*Resolved, (the Senate concurring,)* That twelve thousand five hundred additional copies of the report of the Smithsonian Institution for the year 1870 be printed, twenty-five hundred of which shall be for the use of the Senate, five thousand for the use of the House, and five thousand for the use of the Institution: *Provided*, That the aggregate number of pages of said report shall not exceed four hundred and fifty, and that there shall be no illustrations except those furnished by the Institution."

Attest: EWD. McPHERSON,
Clerk.

LETTER

FROM THE

SECRETARY OF THE SMITHSONIAN INSTITUTION,

TRANSMITTING

The annual report of the Smithsonian Institution for the year 1870.

SMITHSONIAN INSTITUTION,
Washington, March 1, 1871.

SIR: In behalf of the Board of Regents, I have the honor to submit to the Congress of the United States the annual report of the operations, expenditures, and condition of the Smithsonian Institution for the year 1870.

I have the honor to be, very respectfully, your obedient servant,

JOSEPH HENRY,
Secretary Smithsonian Institution.

Hon. S. COLFAX,
President of the Senate.
Hon. J. G. BLAINE,
Speaker of the House of Representatives.

ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION FOR 1870.

This document contains: 1. The programme of organization of the Smithsonian Institution. 2. The annual report of the Secretary, giving an account of the operations and condition of the establishment for the year 1870, with the statistics of collections, exchanges, meteorology, &c. 3. The report of the executive committee, exhibiting the financial affairs of the Institution, including a statement of the Smithson fund, the receipts and expenditures for the year 1870, and the estimates for 1871. 4. The proceedings of the Board of Regents. 5. A general appendix, consisting principally of reports of lectures, translations from foreign journals of articles not generally accessible, but of interest to meteorologists, correspondents of the Institution, teachers, and others interested in the promotion of knowledge.

THE SMITHSONIAN INSTITUTION.

LYSSES S. GRANT.....President of the United States, *ex-officio* Presiding Officer of the Institution.
ALMON P. CHASE .....Chief Justice of the United States, Chancellor of the Institution, President of the Board of Regents.
)SEPH HENRY .....Secretary (or Director) of the Institution.

REGENTS OF THE INSTITUTION.

P. CHASE.....Chief Justice of the United States, *President of the Board.*

COLFAX .....Vice-President of the United States.
ENRY D. COOKE .....Governor of the District of Columbia.
TRUMBULL .....Member of the Senate of the United States.
ARRETT DAVIS.....Member of the Senate of the United States.
HAMLIN.....Member of the Senate of the United States.
A. GARFIELD.....Member of the House of Representatives.
P. POLAND.....Member of the House of Representatives.
S. COX.....Member of the House of Representatives.
. B. ASTOR.....Citizen of New York.
D. WOOLSEY.....Citizen of Connecticut.
AGASSIZ.....Citizen of Massachusetts.

ETER PARKER .....Citizen of Washington.
OHN MACLEAN .....Citizen of New Jersey. } EXECUTIVE COMMITTEE.
'ILLIAM T. SHERMAN..Citizen of Washington.

MEMBERS EX OFFICIO OF THE INSTITUTION.

S. GRANT.....President of the United States.
COLFAX .....Vice-President of the United States.
P. CHASE.....Chief Justice of the United States.
FISH .....Secretary of State.
S. BOUTWELL .....Secretary of the Treasury.
W. BELKNAP.....Secretary of War.
M. ROBESON .....Secretary of the Navy.
A. J. CRESWELL.....Postmaster General.
DELANO.....Secretary of the Interior.
T. AKERMAN.....Attorney General.
D. LEGGETT.....Commissioner of Patents.
D. COOKE.....Governor of the District of Columbia.

EXECUTIVE OFFICERS OF THE INSTITUTION.

JOSEPH HENRY, SECRETARY,

Director of the Institution.

SPENCER F. BAIRD, ASSISTANT SECRETARY,

In charge of Museum, Exchanges, &c.

WILLIAM J. RHEES, CHIEF CLERK,

In charge of Accounts, Printing, and General Business.

DANIEL LEECH, CLERK,

In charge of Correspondence.

CLARENCE B. YOUNG, CLERK,

And Book-keeper.

HENRY M. BANNISTER, CLERK,

In charge of Meteorological Records.

JANE A. TURNER, CLERK,

In charge of Records of International Exchanges

SOLOMON G. BROWN, CLERK,

In charge of Transportation.

JOSEPH HERRON,

Janitor of the Museum.

PROGRAMME OF ORGANIZATION

OF THE

SMITHSONIAN INSTITUTION.

[PRESENTED IN THE FIRST ANNUAL REPORT OF THE SECRETARY, AND ADOPTED BY THE BOARD OF REGENTS, DECEMBER 13, 1847.]

INTRODUCTION.

General considerations which should serve as a guide in adopting a Plan of Organization.

1. WILL OF SMITHSON. The property is bequeathed to the United States of America, "to found at Washington, under the name of the SMITHSONIAN INSTITUTION, an establishment for the increase and diffusion of knowledge among men."

2. The bequest is for the benefit of mankind. The Government of the United States is merely a trustee to carry out the design of the testator.

3. The institution is not a national establishment, as is frequently supposed, but the establishment of an individual, and is to bear and perpetuate his name.

4. The objects of the Institution are, 1st, to increase, and 2d, to diffuse knowledge among men.

5. These two objects should not be confounded with one another. The first is to enlarge the existing stock of knowledge by the addition of new truths; and the second, to disseminate knowledge, thus increased, among men.

6. The will makes no restriction in favor of any particular kind of knowledge; hence all branches are entitled to a share of attention.

7. Knowledge can be increased by different methods of facilitating and promoting the discovery of new truths; and can be most extensively diffused among men by means of the press.

8. To effect the greatest amount of good, the organization should be such as to enable the Institution to produce results, in the way of increasing and diffusing knowledge, which cannot be produced either at all or so efficiently by the existing institutions in our country.

9. The organization should also be such as can be adopted provisionally; can be easily reduced to practice; receive modifications, or be abandoned, in whole or in part, without a sacrifice of the funds.

10. In order to compensate in some measure for the loss of time occasioned by the delay of eight years in establishing the Institution, a considerable portion of the interest which has accrued should be added *to the principal.*

11. In proportion to the wide field of knowledge to be cultivated, the funds are small. Economy should, therefore, be consulted in the construction of the building; and not only the first cost of the edifice should be considered, but also the continual expense of keeping it in repair, and of the support of the establishment necessarily connected with it. There should also be but few individuals permanently supported by the Institution.

12. The plan and dimensions of the building should be determined by the plan of the organization, and not the converse.

13. It should be recollected that mankind in general are to be benefited by the bequest, and that, therefore, all unnecessary expenditure on local objects would be a perversion of the trust.

14. Besides the foregoing considerations, deduced immediately from the will of Smithson, regard must be had to certain requirements of the act of Congress establishing the Institution. These are, a library, a museum, and a gallery of art, with a building on a liberal scale to contain them.

SECTION I.

Plan of organization of the Institution in accordance with the foregoing deductions from the will of Smithson.

TO INCREASE KNOWLEDGE. It is proposed—

1. To stimulate men of talent to make original researches, by offering suitable rewards for memoirs containing new truths; and,

2. To appropriate annually a portion of the income for particular researches, under the direction of suitable persons.

TO DIFFUSE KNOWLEDGE. It is proposed—

1. To publish a series of periodical reports on the progress of the different branches of knowledge; and,

2. To publish occasionally separate treatises on subjects of general interest.

DETAILS OF THE PLAN TO INCREASE KNOWLEDGE.

I. *By stimulating researches.*

1. Facilities afforded for the production of original memoirs on all branches of knowledge.

2. The memoirs thus obtained to be published in a series of volumes, in a quarto form, and entitled Smithsonian Contributions to Knowledge.

3. No memoir on subjects of physical science to be accepted for publication which does not furnish a positive addition to human knowledge, resting on original research; and all unverified speculations to be rejected.

4. Each memoir presented to the Institution to be submitted for examination to a commission of persons of reputation for learning in the

branch to which the memoir pertains; and to be accepted for publication only in case the report of this commission is favorable.

5. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision is made.

6. The volumes of the memoirs to be exchanged for the transactions of literary and scientific societies, and copies to be given to all the colleges and principal libraries in this country. One part of the remaining copies may be offered for sale, and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

7. An abstract, or popular account, of the contents of these memoirs to be given to the public through the annual report of the Regents to Congress.

II. *By appropriating a part of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects and the amount appropriated, to be recommended by counsellors of the Institution.

2. Appropriations in different years to different objects; so that in course of time each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published, with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made.

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, magnetical, and topographical surveys, to collect materials for the formation of a physical atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light; chemical analyses of soils and plants; collection and publication of scientific facts accumulated in the offices of government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches, and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America; also, explorations and accurate surveys of the mounds and other remains of the ancient people of our country.

DETAILS OF THE PLAN FOR DIFFUSING KNOWLEDGE.

I. *By the publication of a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. These reports will diffuse a kind of knowledge generally interesting, but which, at present, is inaccessible to the public. Some of the reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch can procure the parts relating to it without purchasing the whole.

5. These reports may be presented to Congress, for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individuals for a moderate price.

The following are some of the subjects which may be embraced in the reports:*

I. PHYSICAL CLASS.

1. Physics, including astronomy, natural philosophy, chemistry, and meteorology.
2. Natural history, including botany, zoölogy geology, &c.
3. Agriculture.
4. Application of science to arts.

II. MORAL AND POLITICAL CLASS.

5. Ethnology, including particular history, comparative philology, antiquities, &c.
6. Statistics and political economy.
7. Mental and moral philosophy.
8. A survey of the political events of the world; penal reform, &c.

III. LITERATURE AND THE FINE ARTS.

9. Modern literature.
10. The fine arts, and their application to the useful arts.
11. Bibliography.
12. Obituary notices of distinguished individuals.

*This part of the plan has been but partially carried out.

II. *By the publication of separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs translated from foreign languages, or of articles prepared under the direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises should, in all cases, be submitted to a commission of competent judges, previous to their publication.

3. As examples of these treatises, expositions may be obtained of the present state of the several branches of knowledge mentioned in the table of reports.

SECTION II.

Plan of organization, in accordance with the terms of the resolutions of the Board of Regents providing for the two modes of increasing and diffusing knowledge.

1. The act of Congress establishing the Institution contemplated the formation of a library and a museum; and the Board of Regents, including these objects in the plan of organization, resolved to divide the income* into two equal parts.

2. One part to be appropriated to increase and diffuse knowledge by means of publications and researches, agreeably to the scheme before given. The other part to be appropriated to the formation of a library and a collection of objects of nature and of art.

3. These two plans are not incompatible with one another.

4. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies in the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

5. The Institution should make special collections, particularly of objects to illustrate and verify its own publications.

6. Also, a collection of instruments of research in all branches of experimental science.

7. With reference to the collection of books, other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found in the United States.

8. Also, catalogues of memoirs, and of books and other materials, should be collected for rendering the Institution a center of bibliographical knowledge, whence the student may be directed to any work which he may require.

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*The amount of the Smithsonian bequest received into the Treasury of the United States is $515,169 00
Interest on the same to July 1, 1846, (devoted to the erection of the building) 242,129 00
Annual income from the bequest 30,910 14

9. It is believed that the collections in natural history will increase by donation as rapidly as the income of the Institution can make provision for their reception, and, therefore, it will seldom be necessary to purchase articles of this kind.

10. Attempts should be made to procure for the gallery of art casts of the most celebrated articles of ancient and modern sculpture.

11. The arts may be encouraged by providing a room, free of expense, for the exhibition of the objects of the Art-Union and other similar societies.

12. A small appropriation should annually be made for models of antiquities, such as those of the remains of ancient temples, &c.

13. For the present, or until the building is fully completed, besides the Secretary no permanent assistant will be required, except one, to act as librarian.

14. The Secretary, by the law of Congress, is alone responsible to the Regents. He shall take charge of the building and property, keep a record of proceedings, discharge the duties of librarian and keeper of the museum, and may, with the consent of the Regents, *employ assistants.*

15. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit new objects of art. Distinguished individuals should also be invited to give lectures on subjects of general interest.

This programme, which was at first adopted provisionally, has become the settled policy of the Institution. The only material change is that expressed by the following resolutions, adopted January 15, 1855, viz:

Resolved, That the 7th resolution passed by the Board of Regents, on the 26th of January, 1847, requiring an equal division of the income between the active operations and the museum and library, when the buildings are completed, be, and it is hereby, repealed.

Resolved, That hereafter the annual appropriations shall be apportioned specifically among the different objects and operations of the Institution, in such manner as may, in the judgment of the Regents, be necessary and proper for each, according to its intrinsic importance and a compliance in good faith with the law.

REPORT

OF

PROFESSOR JOSEPH HENRY,

SECRETARY OF THE SMITHSONIAN INSTITUTION,

FOR 1870.

To the Board of Regents:

GENTLEMEN: The year 1870 may be considered almost an epoch in the history of the Smithsonian Institution, since in this year Congress commenced to recognize the propriety of making something like an adequate appropriation to relieve the Smithson fund from at least a portion of the burden to which it has from the first been subjected in the maintenance and care of the National Museum. During the last session of Congress an appropriation of $10,000 was granted for the preservation and exhibition of the national collection, and also $10,000 toward the preparation of the second story of the building for the better care and display of the specimens, and an equal sum for each of these objects has been asked at the present session for the year 1871, and we are assured by influential members of Congress that the request will be granted. It cannot be otherwise than gratifying to the friends of science that Government has at length awakened to the importance of making provision for the independent support of a National Museum, which we trust will be worthy of the capital of the United States. The connection which has heretofore existed between the National Museum and the Smithsonian Institution has been alike prejudicial to both, although more than one-half of the income of the Smithson fund has been expended in maintenance of the museum; and notwithstanding that the Institution, in the prosecution of its legitimate objects, has collected many thousands of specimens illustrating the productions of the North American continent, the public museum has not yet, owing to the inadequacy of means, been such as might be expected from the reputation of the Institution or the character of our Government.

The National Museum was established previous to the acceptance by the Government of the care of the Smithson bequest, and consisted at first of the specimens of natural history and ethnology collected by the United States exploring expedition under Admiral Wilkes. Unfortunately, from a misconception of the terms of the will of Smithson, as now generally recognized, Congress directed the appropriation of the income of the fund principally to a museum, a library, a gallery of art, and other local objects, which, though important in themselves, did not comport with the liberal *spirit* of the bequest, nor with the income of

the endowment, which was scarcely more than sufficient to properly support any one of these objects. Had it not been for this misconception, it is not improbable that before this time Congress would have made a more liberal provision for the support of the National Museum, and the scientific operations of the Institution which have made it favorably known throughout the world would have been much more extended. From the first the organic law of Congress has, therefore, stood in the way of the full development of the plan of active operations of the Institution; and it has only been by the gradual enlightenment of the public mind as to the true character of the will of Smithson and the importance of the plan of active operations, that, step by step, and after upward of twenty years of continued effort, the latter has now a fair prospect of producing all the results which have been claimed for it.

As stated in previous reports, the library of the Institution has been incorporated, under certain conditions, with that of Congress. The land around the building presented to the Institution by the Government, and upon which at first about $10,000 of the income of the fund was expended, has been incorporated with the public reservation set aside for a park, and the cost of its keeping defrayed from the general appropriation for the maintenance of the public grounds. The establishment of a gallery of art by the liberal endowment of Mr. Corcoran obviates the necessity of anything further being done in this direction by the Institution.

Still the emancipation of the fund from local objects is not as thorough as could be wished. It would be better, in my opinion, that the public museum should be entirely separated from the Institution. The appropriations of Congress are frequently fitful, and the distinction between appropriations for the museum and for the Institution is not as manifest as is desirable. It is the wiser policy of the Institution to ask no appropriations from Congress for its own legitimate objects, in order that it may be kept entirely free from political influence. We must, however, be content, in the attainment of an object depending upon legislative enactment, with securing a part of what we wish, if we cannot obtain the whole.

Finances.—The following is a general statement of the condition of the Smithson fund at the end of the year 1870, or rather at the beginning of the year 1871:

The amount originally received as the bequest of James Smithson, of England, deposited in the Treasury of the United States, in accordance with the act of Congress of August 10, 1846	$515,169 00
The residuary legacy of Smithson received in 1865, also deposited in the Treasury of the United States, in accordance with the act of Congress of February 8, 1867	26,210 63
Making the bequest of Smithson	541,379 63

Additions from savings, &c., also in the United States Treasury, as a part of the original fund	$108,620 37
In Virginia State stock, $72,760, valued at	48,000 00
Cash on hand	21,477 81
	719,477 81

The income from the fund during the year 1870, including the premium on gold, was $43,363 12. This amount is $6,152 08 less than that for 1869, due to the difference in the premium on coin.

No interest has been received from the State of Virginia for 1869 and 1870. Up to 1870 the usual appropriation from Government for the care of the National Museum was $4,000, but for the fiscal year commencing July 1, 1870, this amount was increased, as we have before stated to $10,000. Of this sum $5,024 have been placed to the credit of the museum; the whole expense, however, of keeping the museum, irrespective of the interest on the building, amounted to at least $15,000.

The remainder of the income (excepting $508 16) was expended in publications, exchanges, researches, salaries, &c., and nearly $5,000 for repairs on the building.

Congress also granted, as previously stated, an appropriation of $10,000 toward fitting up the large hall for the better preservation and display of the collections; but of this nothing has been drawn during the year, the plans and other preparations for the improvement of the building not having been completed. From the foregoing statement it will be evident that the Smithson funds are in a prosperous condition, and that should Congress continue annually to make an adequate support for the museum, they would be sufficient on the part of the institution to extend its usefulness far beyond what it has yet accomplished.

As a part of the history of the Institution, and in justice to the generosity of one of its earliest friends, I may mention under the head of finance, that for many years during the controversy which existed between the regents and the contractors in regard to the building, James M. Carlisle, esq., of this city, acted as counsel for the Institution, and has subsequently given advice on points of law which have arisen in conducting the various operations of the establishment. These services, the usual charges for which would amount to comparatively a large sum, have been gratuitously rendered to the Institution; for which liberality I would recommend a special resolution of thanks by the Board.

Publications.—The publications of the Institution are of three classes—the Contributions to Knowledge, the Miscellaneous Collections, and the Annual Reports. The first consist of memoirs containing positive additions to science resting on original research, and which are gener-

ally the result of investigations to which the Institution has in some way rendered assistance. The Miscellaneous Collections are chiefly composed of works intended to facilitate the study of certain branches of natural history or of meteorology, and are designed especially to induce individuals to engage in studies as specialties, to which in leisure moments their thoughts may recur, and by observations and collections in relation to which they may not only contribute to their own pleasure but, also, advance the cause of science. The Annual Reports are published at the expense of the Government, with the exception of the illustrations, which are furnished by the Institution.

During the past year the sixteenth volume of the Smithsonian Contributions to Knowledge has been published and distributed. It contains 494 pages, and is illustrated with 73 wood-cuts and 19 plates. The several articles contained in this volume, which were also published and distributed separately, are as follows:

The Gray Substance of the Medulla Oblongata and Trapezium, by John Dean, M. D. 4to, pp. 80. Sixteen plates, five wood-cuts.

Results of Meteorological Observations made at Brunswick, Maine, between 1801 and 1859, by Parker Cleaveland, LL.D. Reduced and discussed at the expense of the Smithsonian Institution, by Charles A. Schott. 4to, pp. 60. Eight wood-cuts.

Results of Meteorological Observations made at Marietta, Ohio, between 1826 and 1859, inclusive, by S. P. Hildreth, M. D.; to which are added Results of Observations taken at Marietta, by Mr. Joseph Wood, between 1817 and 1823. Reduced and discussed by the Smithsonian Institution, by Charles A. Schott. 4to, pp. 52. Fourteen wood-cuts.

On the Gliddon Mummy Case in the Museum of the Smithsonian Institution, by Charles Pickering. 4to, p. 6. One plate.

The Orbit and Phenomena of a Meteoric Fire-Ball, seen July 20 1860, by Professor James H. Coffin, LL. D. 4to, p. 56. Two plates two wood-cuts.

On the Transatlantic Longitude, by Benjamin Apthorp Gould. 4to pp. 110.

The Indians of Cape Flattery, at the entrance to the Strait of Fuca Washington Territory, by James G. Swan. 4to, pp. 118. Forty-four wood-cuts.

The Seventeenth volume of Smithsonian Contributions, that for the year 1871, has also been printed, is in the hands of the binder, and will soon be ready for distribution. It consists of a single memoir of 600 quarto pages, presenting the result of an elaborate original investigation by Lewis H. Morgan, esq., of Rochester, New York, on the "Systems of Consanguinity and Affinity of the Human Family."

This memoir, of which an account has been given in a previous report was first referred to a commission consisting of Professor J. H. McIlvaine and Professor William Henry Green, of Princeton, New Jersey, who recommended its publication, but advised certain changes in the method of

presenting the subject. After these modifications had been made, it was submitted to the American Oriental Society, and was by it referred to a special committee, consisting of Messrs. Hadley, Trumbull, and Whitney, who, having critically examined the memoir, reported that it contained a series of highly interesting facts, which, they believed, the students of philology and ethnology, though they might not accept all the conclusions of the author, would welcome as valuable contributions to science.

The investigations of Professor Newcomb, relative to a new orbit of the planet Uranus, in continuation of those relative to the planet Neptune, an account of which was given in previous reports, have been temporarily interrupted by the visit of the author to Europe to observe the total eclipse of last December, and to collect ancient observations for correcting the mean motion of the moon. These investigations were commenced as far back as 1860, but Professor Newcomb had so little time to spare from official duties, and had to depend so much upon himself on account of the methods to be employed, that four years elapsed before even the first formulæ for the perturbations were computed. The best accepted elements of the planets were first used, viz, those of Bouvard for Jupiter and Saturn, and those of Pierce and Kowalski for Neptune. The calculated places of Uranus and Neptune were found from these data to differ so widely from the true ones given by observation as to show that the elements of these planets which had been adopted were not to be relied on. A re-investigation of their orbits therefore became necessary. That of Neptune was made exhaustive. The magnitude of the corrections required in the old elements is shown by the fact that the longitude of the perihelion of Neptune was changed by about four degrees. This investigation was published by the Institution in 1865, and the tables for predicting the position of the planet were immediately adopted by the nautical almanacs of England, Germany, and this country, and afterward by that of France, so that the computations of Neptune's motion are now generally made from them.

The elements of Uranus were next so far corrected by a preliminary investigation, that, with the perturbations already computed, the motion of the planet from the time of its discovery in 1781 until 1862 was represented within a very few seconds of arc. On collecting the perturbations of Saturn there appeared to be considerable discrepancy between the old ones employed in Bouvard's tables and those since computed by Hansen. As there could be little doubt of the correctness of the latter, Professor Newcomb accepted them as the basis of a preliminary investigation of the orbit of Saturn, and obtained elements which represented its motion near enough for the purpose desired. The elements of Jupiter were found to be sufficiently near the truth. The old computations of the "first-order" of perturbations were then corrected, and to guard against the possibility of an error the perturbations were then recomputed by an entirely different method. After long study and labor

the author was enabled to devise a method more simple than any before employed, of which the quantities previously calculated furnished the basis, and which has the great advantage of being easily applicable to the perturbations of the second order. The results of the two computations have been found to agree very closely. The more important terms of the second order have been once computed, but will be gone over again to insure correctness. The most difficult part of the work is now completed. An appropriation has been made by the Institution for defraying the expense of the clerical labor which is required in preparing the tables and performing the other laborious arithmetical calculations necessary in reducing the abstract mathematical results to practical use.

Among the papers accepted for publication are three by Major General J. G. Barnard, United States Army. The first of these relates to the "Precession of the Equinoxes and Nutation as identified with the phenomena of the Gyroscope." All writers who explain the "Precession" in a manner intended to be more or less adapted to popular comprehension, assume or demonstrate certain elementary facts which are common to the general phenomena of the "Precession," and the movements of the philosophic toy, the "Gyroscope." The intention of this paper is to identify the phenomena, and to show that a common analysis leads, when properly adapted to the different circumstances, to their solution. As a matter of course, the introduction of the proper expressions for the external forces into the general equations of rotating bodies will give the particular equations for the special cases. In the Mécanique Céleste, are thus derived the expressions for precession and nutation; but the analytical process is difficult, and the point of identification of the phenomena with those of the gyroscope is, in this point of view, too remote to be interesting. In this paper, solutions primarily obtained for the gyroscope are subsequently made use of to develop all the facts of precession and nutation. By the methods employed it is incidentally shown that the phenomena of "deviation" in rifled projectiles may be explained.

The second paper by General Barnard is on the motions of a "freely suspended pendulum," and differs from other well known discussions of this problem in giving, as a preliminary, a simple explanation of the origin of the forces which, on the surface of the rotating earth, cause a progressive azimuthal motion of the plane of vibration; and furnishing the analytical expressions for these identical with those of Poisson obtained by other processes. These same expressions exhibit forces which more or less sensibly affect *all* motions of material bodies on or near the earth's surface, as *e. g.* the tidal currents, the winds, the trajectories of projectiles, &c. The expressions obtained for the pendulum are developed with much greater detail than has been done in previous works. The differential expressions for the vibrations of the so-called "spherical pendulum" are integrated by development into series, and expressions approximately accurate, obtained for the

azimuthal motion of the apsides of the quasi-elliptical orbit. Inasmuch as in all actual experiments with the freely suspended pendulum the vibrations soon assume the "spherical" character, these latter expressions are really important as corrections to the azimuthal motion properly due to the earth's rotation, and may explain the small variations from the latter which the experiments generally exhibit. It is believed that these corrections have never before been applied, or indeed actually put into simple analytical shape. It is further shown that if a freely suspended pendulum is made to swing through a great circle with very high velocity, the plane of its orbit remains invariable in direction, in space, and that in this phase the phenomenon is identical with that shown by a gyroscopic disk, as it was arranged by Foucault to exhibit the rotation of the earth.

A third paper by the same author is "on the Phenomena of Precession and Nutation as affected by the internal structure of the earth," and is an attempt to corroborate the dictum of Sir William Thompson, that the phenomena of the precession and nutation *do* authorize some conclusions—very limited, indeed—concerning the internal structure of the earth, inasmuch as it is proved that the very commonly received geologic hypothesis of a thin crust enveloping a molten fluid is inconsistent with the actual phenomena as observed.

As the basis of the argument, the theorem is analytically demonstrated that an entirely fluid earth (*i. e.*, entirely destitute of solid crust and without internal viscidity) would exhibit neither precession nor nutation. In other words, that the tilting effects of the solar and lunar attractions would be exactly neutralized by the centrifugal forces due to the tidal protuberances they develop. *Pari ratione*, if the *figure* of the earth yields *at all* to the attractions, the precession and nutation will be neutralized in exact proportion to the extent (as compared with a perfect fluid globe) to which that yielding obtains.

Sir W. Thompson has proved that even an earth entirely *solid must yield*, unless its rigidity to the depth of two or three thousand miles greatly exceeds that of steel; a *thin crust*, say thirty or forty miles thick, such as geological hypothesis attributes to the earth, if enveloping a fluid nucleus, would yield nearly as much as if the earth were entirely fluid. But the observed rates of precession and nutation conform almost exactly to the hypothesis of perfect rigidity. Hence, the hypothesis of a thin crust is *untenable*. Incidentally the fallacy of the experiment (with rotating spherical glass shells, containing water) and argument of M. Delaunay to invalidate the conclusions of Professor Hopkins and Professor Thompson is exhibited, and the opinions of Poisson concerning the internal structure of the earth are, according to the author, shown to coincide better with observed facts than those of any other physicist.

Another paper has been examined and accepted for publication entitled "The Secular Variations of the Orbits of the Planets," by John

N. Stockwell. If but one planet revolved around the sun its path in space would be a true ellipse, which would always be the same in form and position; but if several planets revolve at the same time around the central body, their mutual attraction will disturb the regularity of the elliptical motion. The mutual action of the planets on each other produces two classes of disturbance, one of which consists in a change of the motion of each planet in its elliptical orbit, in some parts of its path moving faster and in others slower than it would if undisturbed; the other consists of a change in the form and relative position of the elliptical orbit. The first is called the periodic inequalities, and the second the secular variations. They are, however, both periodical, though the first runs through its changes in a short time, while the latter requires centuries to complete its cycle. The object of the investigations of Mr. Stockwell is to determine the numerical value of the secular changes of the elements of the orbits of the planets of our system. Several partial solutions of this problem have been obtained by previous authors, but they have been approximations based upon data less perfect than that which is at present afforded in the discovery of the new planet Neptune, and the better determination of the masses of the other bodies composing our system.

The expense of the publication of this paper is defrayed by the liberal donation of $1,200 from a friend of science, who declines to allow his name to be mentioned. We cannot, however, permit the fact to pass unnoticed of this example of the high appreciation of the value of abstract science since it does honor to the intelligence and liberality of one of our citizens engaged in active business life, and may serve as an example to stimulate other donations of a similar character.

In several of the previous reports mention has been made of a grammar and dictionary of the Choctaw language, in process of preparation for the Institution by Dr. Byington, for many years a missionary among the Choctaw Indians. This work was finally submitted to the Institution for publication, but having been found on examination to require corrections it was returned to the author in order that these might be made. Before, however, this work was completed, Dr. Byington died, and his MS. was given for revision to Dr. Brinton, of Philadelphia. It was again submitted to the Institution and referred to a commission for critical examination. Dr. Brinton, however, not satisfied with the report of this commission, withdrew the memoir, and presented it to the American Philosophical Society, in whose transactions it has since been printed. No objection was made on the part of the Institution to this transfer, since it has been from the first a part of its policy never to expend any portion of its funds in doing that which can be done by other means.

It will be remembered that in 1867, at the suggestion and expense of the Institution, a geological exploration of a portion of the Louisiana coast was made by Professor E. W. Hilgard, of the University of Mis-

sissippi, mainly with a view to ascertain the geological age and mode of occurrence of the rock-salt deposit of Petite Anse. In the absence of definite data concerning the general geology of Louisiana, his observations on the formations of the coast (an abstract of which was published in the American Journal of Science, January, 1869) demonstrated, so far as the salt deposit was concerned, only the fact that in point of age it was anterior to the drift. The impulse thus given to geological research in Louisiana, however, soon led to further explorations. By subscription, and a special appropriation obtained from the commissioners of immigration of the State, the New Orleans Academy of Sciences raised a fund for the purpose of enabling Professor Hilgard to make a general geological reconnaissance of Louisiana, which was executed in May and June, 1869. This enabled him to communicate to the American Association for the Advancement of Science, at its Salem meeting, a general sketch of the geology of Louisiana. Almost simultaneously with the organization of Professor Hilgard's second exploration, steps were taken by the faculty of the University of Louisiana to secure legislative aid for a geological and physical survey of the State. The latter is now in progress, and the second annual report on the work will soon be published.

As regards the rock-salt deposit, Professor Hilgard's observations in Northern Louisiana point to the conclusion that it is but one of a series of cretaceous outliers, traversing the State in a northwest and southeast direction, and indicating the existence of an ancient ridge which must have exerted an important influence upon the physical conformation of the Lower Mississippi Valley. The remarkable gypsum and sulphur deposits of Calcasieu are likewise, in his opinion, referable to the same age. Professor Hilgard has nearly completed a final memoir on the geology of the Petite Anse region for publication by the Institution; the results of his simultaneous exploration of the Lower Mississippi and delta having been communicated to the American Association at the Troy meeting, and subsequently presented to the American Journal of Science.

Dr. Horatio C. Wood, of Philadelphia, having completed an elaborate work on the fresh-water algæ, principally of microscopic forms, presented it to the American Philosophical Society and also to the Academy of Natural Sciences of Philadelphia, but the expense of publication prevented either of these societies from undertaking it. It was therefore offered to this Institution, and after a critical examination has been accepted for publication. As a systematic description of the fresh-water algæ of North America it will form a complement to the great works on the marine algæ, by Dr. Harvey, published some years ago by the Smithsonian Institution. It will be copiously illustrated by drawings, made principally under the microscope and will serve to illustrate an obscure department of botany, as well as to furnish the means by which investigators of minute microscopic organisms may make the

comparison of fossil and recent forms, a subject which is now attracting much attention in Europe and America.

The eighth volume of Miscellaneous Collections contains the following papers:

1. Monographs of the Diptera of North America. Part IV. Prepared for the Smithsonian Institution by R. Osten Sacken. 8vo, pp. 358. Four plates and seven wood-cuts.

2. Catalogue of the Orthoptera of North America described previous to 1867. Prepared for the Smithsonian Institution by Samuel H. Scudder. 8vo, pp. 110.

3. Land and Fresh-water Shells of North America. Part I. Pulmonata Geophila. By W. G. Binney and T. Bland. 8vo, pp. 328, and 544 wood-cuts.

4. Arrangement of Families of Birds. Adopted provisionally by the Smithsonian Institution. 8vo, pp. 8.

5. Circular to Officers of the Hudson's Bay Company. 8vo, pp. 6.

6. Suggestions relative to Objects of Scientific Investigations in Russian America. 8vo, pp. 10.

7. Circular relating to Collections in Archæology and Ethnology. 8vo, pp. 2.

8. Circular to Entomologists. 8vo, pp. 2.

9. Circular relative to Collections of Birds from Middle and South America. 8vo, pp. 2.

10. Smithsonian Museum Miscellanea. Pp. 88.

The ninth volume of Miscellaneous Collections contains—

1. Bibliography of North American Conchology previous to the year 1860. Prepared for the Smithsonian Institution by W. G. Binney. Part II. Foreign Authors. 8vo, pp. 302.

2. Catalogue of Publications of Societies and of Periodical Works belonging to the Smithsonian Institution. Deposited in the Library of Congress, 1866. 8vo, pp. 596.

In accordance with the plan adopted by the Institution of furnishing facilities and means of identifying specimens of natural history in its different departments, an arrangement was made with Professor De Saussure, of Geneva, Switzerland, the highest authority on the class of insects known as hymenoptera, (of which the principal forms are wasps, bees, &c.,) to prepare a monograph of this part of entomology. Large collections have been sent to him for the work, to which he has devoted several years of gratuitous labor. The first part of the manuscript was completed in the French language in 1863, and for translation was placed in the hands of a competent entomologist, Mr. Edward Norton, of Farmington, Connecticut, who volunteered his services from a desire of advancing science. This part of the memoir was prepared for the press in 1864, but as Mr. Norton was obliged to be absent from the country several years, the printing was delayed until his return, in order that the proof-sheets might be properly corrected. By this time, however,

so much new material had been collected it was thought advisable to refer the work anew to Professor De Saussure, from whom it has again been received, and after having been a second time revised by Mr. Norton will soon be sent to the press.

The Institution in carrying out its original plan of the preparation of manuals of natural history, has thus made provision for publications on the coleoptera, lepidoptera, neuroptera, diptera, orthoptera, and hymenoptera. Of the few remaining orders, a similar monograph of the *hemiptera*, by P. R. Uhler, esq., has been prepared, and will be published when the funds will permit.

For many years the Institution has intended, in consequence of the scattered nature of the accounts of the botany of the region west of the Mississippi, and the absence of any text-book in which correct descriptions could be found, to publish a complete list of the plants, with all the synonyms and species. For a working botanist, engaged in the study of our western plants, the search for what has been written takes more time and labor than all the rest of his work, besides which there is always the probability of overlooking some writings of importance. The design has not heretofore been carried out, on account of the pressure of other operations, but recently the great need of this aid to botanical research having been urged on the Institution by some of the principal botanists of the country, arrangements have been made with Mr. Sereno Watson, of New Haven, to prepare the work in question. The expense of preparation will be borne by private subscription, the Smithsonian Institution paying for the clerical labor and for the publication. Mr. Watson is esteemed highly competent for the duty intrusted to him, and is favorably known from his labors as botanist of the exploration of the fortieth parallel, under Clarence King, esq. Good progress has been made in the work, and during the year we expect the manuscript to be completed.

In still further pursuance of the plan initiated by the Institution of furnishing aids for the arrangement of collections, as illustrated by its series of check-lists of specimens, an article by Professor Theodore Gill is in process of publication, entitled "An Arrangement of the Families of Mollusks." His system has been adopted provisionally as that by which the extensive collections of the Smithsonian shells are to be arranged and has been approved by some of the principal zoölogists of the country. To extend its benefits, and furnish a similar guide to other museums, the list embraces families, recent and fossil, accepted by the best naturalists of the day, although embodying results of special investigations made by Professor Gill and Mr. Dall at the Institution.

The Annual Report for the year 1869 was printed as heretofore, by order of Congress, but there was a reduction of one thousand in the number of extra copies usually furnished to the Institution. This reduction must have been the result of inadvertence, as we have long urged upon Congress the great demand for the document as a reason

for the increase of the edition, and have been assured by many Senators and Representatives that this would be made. The applications for the report have become so numerous that it is impossible to supply all who are entitled to receive it. In this connection the propriety should be urged upon Congress of ordering new editions of such of the reports as have been stereotyped. The printing of these could be done at very little expense, and would enable the Institution to furnish volumes, for which there is daily application from members of Congress in behalf of libraries and public institutions, to complete sets of the series.

In addition to the report of the Secretary, giving an account of the operations, expenditures, and condition of the Institution for the year 1869, and the proceedings of the Board of Regents, it contains the following articles: Memoirs of Kepler, Thomas Young, Auguste Bravais, C. T. P. Von Martius, and Stefano Marianini; an original paper on the chemistry of the earth, by T. Sterry Hunt; articles on the electrical currents of the earth; phenomena of flight in the animal kingdom; the northern seas; report on the transactions of the Society of Physics and Natural History of Geneva; an original article relative to Coronado's march in search of the seven cities of Cibola, and a discussion of their probable location; social and religious condition of the lower races of man; principles and methods of palæontology; remarks on the Cara Gigantesca of Yucatan; forests and their climatic influence; meteorites; remarkable forms of hail-stones in Georgia; eruption of the volcano of Colima. It is proper to remark that the article on the flight of birds was translated from the French by Mr. W. H. Dall, whose name was accidentally omitted at the head of the article.

For the purpose of forming a general map of the North American Continent, exhibiting the plains, mountains, valleys, &c., the Smithsonian Institution has collected a large amount of material relative to *altitudes*, which has been placed in the hands of W. L. Nicholson, esq., topographer of the United States Post Office Department, to be discussed and elaborated.

There must, however, still remain in the hands of individuals and corporations records of an important character, which would be of great value in properly carrying out the enterprise. The correspondents of the Institution are requested to send to it printed copies or original manuscripts of records, especially of plotted profiles or maps, pertaining to this subject.

In stating the heights, as furnished by surveys for railroads, whether actually constructed or only projected, it is desirable that the levelings be referred to some known point on connecting or intersecting roads, or to the water-surface (high water, low water, or mean tide) of the ocean or of one of the great lakes, or to the level of a noted stage of water (high or low) of some river. The crossings of the water-courses, ridges, and summits are particularly desired, as well as all considerable and characteristic changes of level, giving, where much difference exists,

both grade-line and original surface; the levels of all intersections with other roads are important as means of comparison, and for checking results. Due credit will be given to all contributors to this work.

Exchanges.—The system of international exchanges, established by the Institution, has been continued with unabated zeal during the past year. The number of foreign establishments to which the Smithsonian and other publications are distributed, and from which returns are received now amounts to over seventeen hundred. It includes not only all the first-class libraries and societies which have established a reputation, but also a large proportion of the minor institutions of the Old World. The following table exhibits the number of foreign institutions in each country with which the Smithsonian Institution is at present in correspondence:

Sweden	19	Turkey	10
Norway	11	Africa	14
Iceland	2	Asia	30
Denmark	25	Australia	25
Russia	154	New Zealand	10
Holland	59	Polynesia	1
Germany	529	South America	31
Switzerland	54	West Indies	6
Belgium	119	Mexico	5
France	80	Central America	1
Italy	141	British America	27
Portugal	5	General	5
Spain	9		
Great Britain and Ireland	286		1,744
Greece	6		

During the year 1870, 1,805 packages, containing many thousand different articles, were transmitted to foreign countries. These packages were contained in 121 boxes, having a cubical content of 1,189 feet, and weighing 31,383 pounds. The parcels received at the Institution for parties in this country numbered 3,705. The separate volumes contained in these parcels would largely increase the number, the Institution having received 5,182 articles for its own library. The war between France and Germany, which commenced in July, affected, in some degree, the number of packages received from these countries, and it is probable that the result of this unfortunate conflict will be still more marked in the diminution of the number of scientific publications which may be received from Europe in the year 1871. The Smithsonian packages are passed through all the custom-houses of the world free of duty. The only exception which existed at the date of the last report was that of Italy, and through the intervention of the American minister, Hon. Mr. Marsh, the Italian government has since granted the same privilege.

As in previous years, the Institution has received great benefit from the privileges of free freight for its packages, accorded by a large number of steamboat and railroad lines of transportation. In this report, as in former ones, reference should be made to the liberality of the Pacific Mail Steamship Company; of the Panama Railroad Company; of the Pacific Steam Navigation Company; of the New York and Mexican Steamship Line; of the New York and Brazilian Line; of the North German Lloyds; of the Hamburg American Packet Company; of the French Transatlantic Company; of the Inman Line; and of the Cunard Line. I am happy to announce that to the foregoing list is to be added the Anchor Line of steamers between New York and Glasgow, of which Messrs. Henderson & Brother are the New York agents; and I would recommend that an official acknowledgment be made, on the part of the board, to these gentlemen for their courtesy in offering to the Institution the same privileges accorded by the other New York lines. The Union Pacific Railroad Company has granted free transportation, although thus far we have not been able to avail ourselves of the privilege. The Adams Express Company also continues its liberal policy in regard to our freight. It would be quite impossible for the Institution, without the aid thus liberally afforded, to carry out, in its full efficiency, its system of international exchanges, which, by facilitating the intercourse of scientific institutions and of students throughout the world, constitutes one of its most important features.

It is also my duty, as well as a great personal gratification, to inform you of the liberality of several of these companies, extended to myself on the occasion of the visit to Europe which I made during the past summer, in obedience to your authority; the agents of the North German Lloyds, Messrs. Schumaker & Co., of Baltimore, and Messrs. Oelrichs & Co., of New York, as well as Mr. C. G. Francklyn, the agent of the Cunard steamers, having offered me a free passage across the ocean.

Library.—As in previous years, large accessions have been made to the library of the Institution, principally through the system of international exchanges. The following is a statement of the number of books, maps, and charts received during 1870, most of which have been deposited in the National Library in accordance with the arrangement entered into several years ago, and fully explained in preceding reports:

Volumes:		
Octavo or less	842	
Quarto or larger	270	
		1,11
Parts of volumes:		
Octavo or less	1,263	
Quarto or larger	561	
		1,82

Pamphlets:		
Octavo or less	1,764	
Quarto or larger	302	
		2,066
Maps and charts		179
Total receipts		5,182

The following are some of the larger donations received in 1870:

From the ministry of the interior, Christiania, Norway, "Den Norske Lods;" 2 volumes, octavo, and 71 charts.

From the Imperial Botanical Garden, St. Petersburg, "Sertum Petropolitarum seu icones et descriptiones plantarum quæ in Horto Botanico Imperiali Petropolitano floruerent." Parts I and II, 1846; III and IV, 1869. Folio.

From His Majesty the King of Prussia, "Danzig und seine Bauwerke in malerischen Original-Radirungen mit geometrischen details und text, Von Johann Carl Schultz;" volumes I–III, oblong folio.

From Dr. Koch, Berlin, 127 pamphlets, University Theses.

From the Royal Public Library, Dresden, "Riedel's Codex Diplomaticus Brandenburgensis;" 41 volumes, quarto.

From the Agricultural Association, Potsdam, "Zeitschrift;" volumes III–XVIII, octavo. "Monatschrift," volumes XIX–XXIII, octavo; and "Amtliches Vereinsblatt," 1869, quarto.

From the Austrian government, "Reichs-Gesetz-Blatt für das Kaiserthum Oesterreich;" 1849–1869, quarto, 21 volumes.

From the Musée de Douai, "Dictionnaire des Sciences Médicales;" volumes I–LX, quarto.

From the minister of public instruction, Florence, 11 volumes "On Education, Public and Private."

From the minister of public works, Florence, 25 volumes and 16 pamphlets. Hydraulics, Navigation, and Engineering, &c.

From the meteorological office, London, "Daily Weather Reports," July 1, 1868, to June 30, 1870, (4 volumes and 6 parts,) folio; and "Quarterly Weather Report," part I.

From William Blackmore, esq., Liverpool, "Hoare's Ancient History of Wiltshire," volumes I and II, folio, beautifully illustrated with maps and plates. "The People of India: A series of photographic illustrations, with descriptive letter-press;" volumes I–IV, 1868, quarto. "Tree and Serpent Worship, or Illustrations of Mythology and Art in India in the First and Fourth Centuries after Christ;" quarto; and various other works.

From the State of Illinois, State documents, 14 volumes.

The incorporation of the library of the Institution with that of Congress continues to be productive of the results which were anticipated from this union. The extensive series of transactions of learned

societies, the number of sets and volumes of which are constantly increasing through the Smithsonian exchanges, is an important feature of the National Library, while the use of the books on special subjects belonging to the Government greatly enlarges the facilities for investigation of the collaborators of the Institution. From the first a harmonious co-operation has existed between the two establishments, and on all occasions we have found Mr. Spofford, the accomplished librarian of Congress, ready to consult the interests of the Institution, and insert on his list of purchases any work which we might indicate as desirable for scientific research. Professor Gill, formerly in charge of the Smithsonian library, and now one of the principal assistants in the Library of Congress, still continues his connection with the Institution, and in spending, as he does, most of the hours unemployed in official duty in scientific research at the Smithsonian building, affords the means of constant communication.

The National Library is rapidly increasing in value, both in regard to the number and the character of the books which are annually added to its collections. The sources of increase are, first, the books purchased by the liberal appropriation of Congress; second, the Smithsonian exchanges; and, third, the deposit of books in accordance with the copy-right law. From this last source it has lately received a very large addition of all the American works secured by copy-right since the first enactment of the copy-right law, and previously in charge of the Secretary of the Interior. These books exhibit the phases of thought and the progress of the mental activity of this country for nearly half a century, and have, therefore, a special value independent of their literary or scientific character.

At the time of the organization of the Smithsonian Institution, Congress directed that in order to secure the right of authorship of a book three copies of it should be deposited as evidence of title, one in the library of the Institution, another in that of Congress, and a third in the office of the United States district court. In the case of a costly work, perhaps in several volumes, this was a tax on the author or publisher for the protection of his property which was not improperly considered oppressive. From considerations of justice, therefore, as well as of a prudent regard to the cost of the care of these books, the Smithsonian Institution was the first to petition Congress that the law might be so modified that only two copies should be required to be deposited as evidence of title, and these in the Library of Congress. The proposition suggested in this petition was adopted, and I believe the law enacted in accordance with it now meets with general approbation. It is of some importance that this fact should be mentioned, because copies of books are still occasionally sent to the Institution from a want of a knowledge of the existing law.

Besides the general library of the Government in the Capitol each of the separate Departments, as well as several of the bureaus, has a spe-

cial library. When we add to these the Washington Library and that of the Young Men's Christian Association, the aggregate of the books in the city of Washington must be greater than that in any other city in the country in proportion to the population. Unfortunately, however, these collections are not at present as readily accessible to the public as could be desired. The rapid increase, however, of the National Library will soon render the erection of a separate building absolutely necessary, and in the new arrangement which will result from this, the different libraries can, perhaps, be brought into harmonious relation, and while provision is afforded for the accommodation of a much larger number of readers, the number of hours during which the books are accessible may be increased.

Explorations and collections.—The Institution has continued, during the past year, as heretofore, to prosecute researches and explorations in ethnology and natural history, both by detailing special agents for particular work, and by co-operating with private individuals and Government expeditions, in securing the desired result.

Among the more important of the first-mentioned class was an investigation among the mounds of Tennessee, under Mr. J. P. Stelle. This gentleman spent a number of months in examining carefully several groups of ancient mounds, and has furnished an interesting account of his researches, accompanied by topographical drawings of the localities, and large numbers of specimens, obtained in the course of his explorations. The report of Mr. Stelle will be printed in the appendix to the annual report of the Institution.

Professor Baird, during his visit to Wood's Hole, in Vineyard Sound, continued his investigations of previous years among the shell-heaps of the coast, and added largely to the collection in archæology. He also devoted much attention to the study of the habits of the marine fishes of that part of the coast. Under the special direction of Professor H. E. Webster, a system of dredging was carried on in the same locality, from which an interesting series of mollusca and other marine animals was procured.

Captain Dow, of the Panama Railroad service, has furnished important collections from Central America, among them the skulls of what will probably prove to be a new species of tapir. Mr. Durkee, of Wyoming Territory, has supplied a large number of specimens of nests and eggs, with fossils and other objects from his locality, embracing several species not before in the collection.

The largest collections, however, received during the year, are those made by Professor Hayden, as United States geologist for the Territories. These, in accordance with the law of Congress making the Institution the depository of all objects of nature and art, natural history, etc., belonging to the United States, have been sent from time to time to the Institution, forming an aggregate of about sixty boxes, and em-

bracing large numbers of new species of fossil mammals, reptiles, and fishes, with other interesting objects.

Mr. R. McFarlane, Mr. James Lockhart, and Mr. Strachan Jones, who have been extremely liberal to the Institution in previous years, have again made important additions to its store of specimens, illustrative of the natural history of the region of the far northwest.

In accordance with the understanding between the Institution and the Medical Department of the Government, the specimens of human crania obtained by us have been transferred to the Army Medical Museum, which has, in turn, sent to the Institution all other articles it had received in ethnology and archæology. By this means a very extensive and valuable series of specimens has been obtained by the Institution during the past year. A full list of the additions thus made, will be found in the appendix to the present report.

Another collection worthy of special mention was presented to the Institution by the Colonial Museum, at Wellington, New Zealand. This consisted of bones of the *Dinornis*, the skins and skeleton of the *Apteryx*, skins of other birds, shells, and ethnological specimens of the country, and was partly in return for a valuable series of books presented by the Institution to the colonial government.

The labors of Dr. Edw. Palmer, already well known in connection with the ethnological museum of the Institution, have been continued during the present year, and large numbers of articles of Indian manufacture, both ancient and modern, attest his zeal and success as a collector. A more detailed report will be made upon these when the entire collection is received. Lieutenant Ring, of the Army, has continued his valuable donations from Alaska, embracing specimens of animals as well as Indian relics of great antiquity. From Captain C. M. Scammon, of the United States revenue marine, we have received a number of specimens and several important communications in reference to the seals and whales of the Pacific coast. A memoir submitted by this gentleman to the Institution has been published by the Philadelphia Academy of Natural Sciences, and is considered an important contribution to the knowledge of the subject already existing. Dr. G. M. Sternberg and his brother, Mr. C. H. Sternberg, have transmitted extensive and valuable collections of the tertiary fossil plants of Kansas, and other objects of interest. The former have been found, on examination by Mr. Meek, to contain a number of new species, which will shortly be described.

It will be remembered that an exploration of the Isthmus of Tehuantepec, by Professor Sumichrast, has been in progress for some years past, under the direction of the Institution, the expense of which was defrayed in part by the Kentucky University at Lexington, by the Boston Society of Natural History, and by the Academy of Natural Sciences of Philadelphia. The labors of Professor Sumichrast were brought to a close during the past summer, and several of the collaborators of the Institution are now at work in investigating particular

branches of the collection with a view to prepare reports on them. The birds of the collection are in charge of George N. Lawrence; the insects, of Mr. Scudder; the shells, of Mr. Bland; and the reptiles and fish, of Mr. Cope. The series is very complete, and is believed to express essentially the zoölogical character of an interesting portion of Mexico. As specially noteworthy in this connection, is the donation by the Imperial Zoölogical Museum of Vienna, of the skin and skeleton of the European aurochs. This animal, according to Professor Baird, is a species of bison, and very closely related to the American buffalo, if, indeed, it be not, as some naturalists assert, the same. It was formerly found in abundance in Europe, and is mentioned by Cæsar, Tacitus, and other classical writers. It has been almost entirely exterminated, existing at the present time only to the number of a few head in Lithuania and in the Caucasus. The European specimens are preserved with jealous care by the Russian authorities, and severe penalties are imposed for killing or even injuring them.

The number of donations to the collection of the Institution received during the past year is so large that we find it impossible at this time to give to each that special mention which it deserves. A list of them, however, with the names of the donors, will be found in the appendix to the present report; and I embrace this opportunity to express the thanks of the Institution to all who have thus aided in furthering its objects, and to invite their kind co-operation for the future.

The usual statistics in regard to the number of specimens catalogued during the year, and the extent to which the distribution of duplicates has been made, will be found in the accompanying tables. It will be seen that the average of the past years has been fully maintained, and that as far as the material and force at the command of the Institution would permit, the work has been faithfully carried on.

The museum.—Congress having made an appropriation for the better display of the specimens belonging to the Government, it becomes a matter of importance to carefully consider the character which is to be given to the national museum. There is scarcely any subject connected with science and education to which more attention is given at the present day than that of collections of objects of nature and art, known under the general denomination of museums. This arises from their growing importance as aids to scientific investigation and instruction. As they are intended to subserve different ends they are of different characters. There are, on the one hand, large central museums supported by Government appropriations, and on the other, local museums which are established and sustained by societies and voluntary individual aid. The latter are established in almost all parts of the Old World, and are becoming somewhat numerous in this country. The special aim of the directors of these should be to make full collections of all the objects of natural history in their vicinity, not only for the instruction of

the members of the society, and to diffuse a taste for the refined, intellectual pleasure, which is derived from the minute observation of the natural world, but also to furnish lists of local floras and faunas, and of mineralogical and geological localities which may serve to establish the area of distribution of special objects of nature, and thus contribute to the extension as well as the diffusion of knowledge. The directors of museums of this character ought to be careful not to attempt to form general collections, other, perhaps, than a limited number of specimens for comparison, since it will soon be found that the cost and labor of the proper care and exhibition of the local collections will equal the means which can be commanded for this purpose.

Large museums or collections supported by Government appropriations are of different characters, in accordance with the objects they are designed to subserve. They may be intended exclusively for scientific research, and for this purpose consist of large numbers of specimens and duplicates, as it were, of the raw materials of science, which have never been investigated, but which may serve for the study, of the productions of entirely unexplored regions. It has been the policy of this Institution to make collections of this kind, to submit them to experts for critical examination, and to publish such descriptions as would render them subservient to the progress of scientific generalization. If these descriptions were exhaustive, the original specimens would no longer be required for further scientific investigation; but, unfortunately, the characteristics and peculiarities of the specimens are only partially recognized and represented at any one period, and hence it becomes necessary from time to time to go over the same ground in order to verify or disprove new and ingenious suggestions as to peculiarities and relations not hitherto recognized; the specimens must therefore be preserved, especially if they are of such a character as cannot readily be replaced. In making such collections the Smithsonian Institution has done, perhaps, more than any other establishment during the twenty-four years of its existence. It might, however, have effected much more good and extended its influence more widely if all the duplicate specimens had been made up into sets and distributed soon after they were collected. But this was impossible with the limited means at the command of the Institution and the assistance it could obtain from voluntary unpaid collaborators. Besides this, some advantages have resulted to science from the retention in the Institution of a large number of every variety of a class of specimens. This has enabled the naturalist to make comparisons which would have been otherwise impossible, to mark peculiarities connected with age, sex, food, climate, etc., and to observe the diversities of form and structure due to the varying conditions of life. As an illustration of this remark we may refer to the results which Professor Baird has been enabled to arrive at from the unrivalled opportunity which he has had in the extensive collection of the Institution, of

studying the relations of nearly sixty thousand specimens of the birds of North America.

The object of the collection we have just described is exclusively the advance of science. The specimens require comparatively but little space for use and preservation. Not being intended for public exhibition they need not be mounted, but may be kept in drawers, or packed away in labeled boxes or casks until wanted for a special investigation.

Another class of large museums are of a mixed character, combining in their object scientific investigation with special systematic and collegiate instruction. Of this class is the great museum at Cambridge, supported principally by the State of Massachusetts, and under the direction of Professor Agassiz. This museum, which may be considered a model of its class, embraces—first, an immense number of original specimens, in the study and description of which a number of accomplished naturalists are continuously employed; second, a series of specimens which have been scientifically described, and so arranged in accordance with their affinities as to enable the student in any branch of natural history to obtain, with the least expenditure of labor, a definite knowledge of what is known of the objects to which he is devoting his attention; third, a series of specimens of genera so arranged as to serve as illustrations of the courses of lectures to the students of the university on such general principles of natural history as form an essential part of a liberal education. This museum, therefore, affords ample means for the advancement of science by original investigation; for the special training of students who desire to devote themselves to natural history, and for collegiate instruction, while the facilities which it is calculated to afford in these lines are only limited by the funds which it can command.

Another class of museums supported at the public expense are those intended almost exclusively for popular instruction and amusement. Museums of this class have been established in several of the principal cities of Great Britain, and I doubt not that the beneficial effects they are producing will induce other cities to follow their example. The most important of these is the one at Liverpool, in which series of generic specimens are admirably mounted and so arranged as to clearly exhibit their relations and affinities. They are, moreover, all distinctly labeled, so that the visitor, almost without an effort, receives definite impressions, valuable in themselves, and which, by association of ideas, become more important as centers around which other ideas, derived from future reading and observation, may be clustered. The impressions made through the eye are not only the most definite, but also the most indelible. Museums of this kind ought to be established at the public expense in every city or community which can afford the means for their support. So popular are collections of objects of natural history and ethnology, that large establishments of mere heterogeneous materials are frequently sources of profit to those to whom they belong.

In some cases, in a better class of museums, a small admission fee is demanded, and the whole proceeds of this expended in sustaining and enlarging the collections. As an example of this I may mention the public museum established by Mr. Woodward in San Francisco, which is not only a source of continued amusement to the inhabitants of that city, but also a means of adult education, since the specimens are generally well classified and properly labeled. Advantage should be taken through museums, of a feature of the human mind essential to progress, the desire for novelty, to lead the public to the employment of the intellectual pleasure derived from the study and contemplation of nature. It is truly surprising how tastes may be formed, how objects before disregarded may, when viewed as a part of a natural family, be invested with attractions which shall ever after render them sources of refined pleasure and unalloyed enjoyment.

While the Smithsonian Institution should continue to devote a portion of its own funds to assist in explorations which have for their object the advance of science, the public museum, with the care of which it is intrusted by Congress, should, in my opinion, without detracting from its scientific character, largely partake of the popular element. It is to be supported by the Treasury of the United States, and should, therefore, be an object of interest to the large number of visitors who are annually drawn to Washington by curiosity or otherwise, and who cherish a patriotic pride in whatever redounds to the reputation of the national capital.

Besides specimens properly labeled for study, especially of the continent of North America, it should contain those to fully illustrate in part, at least, the more prominent divisions of the animal, vegetable, and mineral kingdoms. These should be so arranged, regard being had to artistic effect, as to exhibit the principles of classification, the relation of organs to one another and to those of their allies, the phases of their organization, and other peculiarities relating to their habits and places in the economy of nature. To assist in this, models and pictorial illustrations of magnified smaller parts and of minute structures should be supplied. In every instance the objects should be accompanied with copious legible descriptions, and in no case should a group contain a single specimen more than is absolutely necessary for the general purpose. Economy of space in a public museum should never be consulted at the expense of clearness of illustration. The national museum should contain skeletons in the original, or casts in plaster, of all the larger fossil animals—sections and scenic representations on a large scale of geological periods, and modeled figures of the different races of men and species of animals.

The space which is at present available in the Smithsonian building for a general public museum consists of the following apartments:

1. On the first floor a room 200 feet long and 50 feet wide. 2. Another large room, in the west wing, 65½ feet long by 35 feet wide, with a

semi-circular projection at one end. 3. A connecting range of 60 feet long by 37 wide. 4. In the second story a single large room of 200 feet long and 50 feet wide. The large room on the first floor is not well adapted to the display of specimens, since it is occupied through its whole length with two rows of colossal columns. The upper room, however, as well as that in the west wing of the building, is entirely free from all hindrance to an arrangement with a view to the best exhibition of the collections. I have said that the rooms above mentioned constitute the present available space for the accommodation of the museum. When, however, more space is required, the eastern wing, now in part occupied as a residence by the Secretary, can be employed for the purpose. The floor and partitions which separate the several apartments of this portion of the building are of a temporary character and can be readily removed. The lower part of this wing and its basement are now used for containing the exchanges and as store-rooms for duplicate specimens of geology and mineralogy. In accordance with the views which have been presented, it is intended to devote the whole of the large room in the second story of the main building to archæological objects with skeletons, life-size drawings, and restorations of the larger mammals contemporary with primitive man, especially on the continent of America. Second, to appropriate the wall-surface and a part of the floor-space of the western wing of the building to mineralogy and geology. The portions of the extensive walls of this room can be covered on the east side, which presents an unbroken surface above the top of the cases of 65 feet by 10 feet, with a geological section across the continent, and the opposite wall with drawings of the characteristic fossils of the strata which are exhibited on the eastern wall. The side and mineral cases for containing the specimens, besides exhibiting a characteristic series of specimens, to represent general geology, mineralogy, and palæontology, will be occupied with full sets of specimens to illustrate the geological formation of North America, and especially the mineralogical resources of this country.

The collection of objects to illustrate anthropology now in possession of the Institution is almost unsurpassed, especially in those which relate to the present Indians and the more ancient inhabitants of the American continent. An artistic and scientific exhibition of these in the large room we have mentioned, could not fail to be highly interesting to the general public, the student of ethnology, and especially to the many intelligent foreigners who visit the capital of the United States. There are also in the collection of specimens in charge of the Institution full sets of all the rocks and minerals collected by the several exploring expeditions which have been sent out by the General Government, besides those which have been presented as free gifts or in exchange to the Institution from all parts of our continent. We can, therefore, with scarcely any additional material, or only with such as can be readily obtained, render the national museum much more

creditable to the Government and the Institution than it has ever yet been. Such a collection will tend to draw to itself numerous isolated collections, especially of anthropology, which, though they may be of much interest to the individuals possessing them, are of comparatively little value in the way of advancing a knowledge of the subject to which they pertain, and, in case of the death of the owners, are generally dissipated and frequently lost to the world. The only way in which they can become of real importance is by making them part of a general collection, carefully preserved in some public institution, where they can be studied and compared with other specimens, and where, in the course of the increasing light of science, they may be made to reveal truths beyond present anticipation.

Herbarium.—An account of the transfer of the extensive collection of plants of the Institution to the care of the Department of Agriculture has been given in previous reports, but it is thought important to place on record a more detailed history of this collection than has yet been published, and I therefore present the following account of it from notes furnished by Dr. Torrey.

The Institution having accumulated a large number of botanical specimens collected in various parts of the world, most of them brought home by the Government exploring expeditions, others presented by authors of botanical works, travelers or special collectors, the offer was made by Professor John Torrey to arrange, without compensation, all these separate collections into one general herbarium. This offer was gladly accepted on the part of the Institution, and all the specimens on hand, and all that were subsequently received up to 1869, were transferred to him. When he commenced the task, the specimens, especially those collected by the Institution, were still in bundles as they were received, and all required to be poisoned to prevent their destruction by insects, which had already commenced their ravages. The plan adopted by Dr. Torrey for the arrangement of the plants was of the most approved character. Each species, often represented by several specimens, and all the marked varieties, are fastened to a half sheet of strong white paper and labeled. All the species of a *genus* are laid on one or more whole sheets of thicker tinted paper, on the lower left-hand corner of which the generic name is written. The genera are arranged according to the natural system, following for the most part the order of De Candolle. A very large proportion of the specimens are authentically named by the authors who have described them; and as they are the type-specimens or originals of several important works are invaluable for reference. Some of the more valuable portions of the Smithsonian herbarium are the following:

1. The plants collected by the exploring expedition under the command of Admiral Wilkes, during the years 1838 to 1842. Many countries were visited in this voyage round the world, and an extensive herbarium

brought home. The botanists of the expedition were Mr. William Rich, Dr. Charles Pickering, and Mr. W. I. D. Brackenridge. To the last-named gentleman was assigned the description of the ferns, his report on which was printed by order of Congress in a handsome quarto volume, with a folio atlas, containing beautifully engraved figures of the new or little-known species. After a very few copies of this work were distributed, the remainder of the edition was destroyed by fire while in the hands of the binder. The copper-plates, however, are still in the custody of the Library Committee of Congress, and it would cost but little to print a new edition of a work so much desired by a large number of botanists. The flowering plants, with the exception of those collected in California and Oregon, were referred to Dr. Torrey; others were partially studied by Mr. Rich, and then committed to Professor Asa Gray for a more thorough investigation. Of this portion of the collection only one quarto volume of text, and a large folio volume of illustrations, have thus far been published by Congress. For a number of years the publication of the works relating to the exploring expedition was in charge of the Joint Library Committee of Congress and Admiral Wilkes, but it was impossible to procure appropriations to defray the large expense of the undertaking. At length all the materials were transferred to the Smithsonian Institution, provided it would publish for distribution an edition of the whole. The limited income of the Smithsonian fund did not permit the Institution to embark in so formidable an undertaking, and plates, manuscripts, and printed matter are still in possession of the Committee on the Library of Congress.

Professor Gray is ready to go on with his work as soon as provision is made for its publication. Dr. Torrey's report has been long since completed, and the illustrations drawn, engraved, and even printed. At this late day, however, the report would require revision; indeed, so many new and rare species described in it have since been found and described by other botanists, that it may be sufficient to publish a very brief report, accompanied by the plates alluded to above. The *Mosses* were described and beautifully illustrated by W. S. Sullivant, esq., of Columbus, Ohio. The text in quarto of his valuable report is also printed, but not published. He has, however, at his own expense, printed for private distribution a beautiful edition of it in folio. The *Algæ* were committed to Professor J. W. Bailey, of West Point, and Professor W. H. Harvey, of Trinity College, Dublin, whose report on these plants, with elaborate illustrations, is printed, and has been, for years, stored away in sheets awaiting to be bound up and published with Dr. Torrey's report. The same may be said of Professor Tuckerman's account of the *Lichens*, and of the reports by Rev. M. A. Curtis, of North Carolina, and Rev. Dr. Berkely, of England, on the *Fungi*.

2. The next most extensive and valuable portion of the herbarium is the collection of plants made during the North Pacific exploring expedition, under command of Commanders Ringgold and Rodgers, from 1853

to 1856, by Mr. Charles Wright, an accomplished botanist, who accompanied the Mexican boundary commissioners in their surveys, and who has also made extensive botanical explorations in Cuba. There has been no full report of the collections made on the North Pacific expedition, though many of the new species have been published by Dr. Gray.

3. The naturalists who accompanied most of the surveying parties which made explorations for the route of a Pacific Railroad collected large numbers of plants, many of which were new to the botanist, and have been described in the published reports of these explorations.

4. Collections made in the Mexican boundary survey by Dr. C. C. Parry, Dr. J. M. Bigelow, Mr. C. Wright, Professor George Thurber, and Mr. Arthur Schott, are among the most extensive and valuable portions of the herbarium. A full account of them, by Drs. Gray, Engelmann, and Torrey, is contained in General Emory's report. The Cactaceæ, and one or two smaller orders, were described by Dr. Engelmann; the Compositæ, Scrophulariaceæ, and one or two other orders, by Dr. Gray; and the ferns, with their allies, by Professor D. C. Eaton. The remaining Cryptogamia are not included in the report, but most of the new or rare ones have been published elsewhere. The grasses were to be described in a separate memoir by Professor Thurber.

5. Large additions have been made to the North American portion of the herbarium, chiefly from within the limits of the United States and Territories, by contributions from the following places: New England, by Mr. Oakes, Dr. Gray, Professor Tuckerman, S. T. Olney, esq., Professor D. C. Eaton, and others; New Jersey, by Mr. C. F. Austin, Professor Eaton, Dr. Torrey, and Dr. Knieskern; New York, Messrs. Austin, LeRoy, Clinton, Torrey, and many others; Pennsylvania, by Dr. Darlington, and Professor Thos. C. Porter; North Carolina, by Rev. Dr. Curtis; Florida, by Dr. Chapman, (type-specimens of his flora of the Southern States;) Alabama, by Professor Winchell; Kentucky, Dr. Short, and Mr. Sullivant; Texas and New Mexico, Messrs. Fendler, Ervendberg, and others, besides what the botanists collected in the Mexican boundary survey; Rocky Mountains, Dr. Parry, Captain Macomb, and Dr. Newberry; Oregon, Mr. Geo. Gibbs, and others; Nebraska, Dr. Hayden; Nevada, Mr. Stretch; California, Dr. H. M. Bolander, General Frémont, Miss Davies, Th. Bridges, Mr. E. Samuels, Dr. Torrey, and many others; Colorado, Dr. Anderson, Frémont, and others. Besides these principal sources of United States plants, very many specimens have been received from other places and persons, which we have not space to enumerate. From British America, especially the sub-arctic portions, Dr. Kennicott, and officers of the Hudson's Bay Company have furnished specimens. Of foreign plants, besides those collected in the two United States exploring expeditions already noticed, the herbarium contains valuable and large contributions from Japan, Mantchuria, China, etc., from Professors Reïgel and Maximovitch, of the Imperial Academy of Science of St. Petersburg, and the Imperial Botanic Garden: A

large collection of Sandwich Island plants, (all type-specimens,) made by Mr. Horace Mann, lately deceased: A collection of plants from Mirador, Mexico, by Dr. Sartorius: Many specimens, with fleshy fruits in alcohol, collected on the Panama Railroad, by the late Dr. Sutton Hayes; others from the same region by Fendler, in 1850: Plants from Jamaica, especially ferns from Mr. Wilson; from Cuba, collected by Mr. Chas. Wright; Venezuela, many beautifully dried ferns by Fendler; from Texas and Northern Mexico, by Berlandier; Lower California, by Mr. Xantus; Brazil and Paraguay, by unknown collector. From Europe, there is an extensive collection of Hungarian plants from Mr. Arthur Schott, and of Illyrian plants from Professor Thomasini, besides many smaller collections from various parts of the continent. Dr. Torrey has contributed a large number of specimens from his own herbarium.

As to the disposition made of the duplicates of the collections, they have been sent in the name of the Smithsonian Institution to learned societies, botanic gardens, and individuals, whenever they could be disposed of for the advance of science. Full sets of duplicates were presented to the Royal Garden at Kew, near London, the botanic gardens of Paris and St. Petersburg, besides smaller portions to individuals, lyceums of natural history, and colleges.

This collection of plants has been transferred to the Agricultural Department, on the conditions set forth in the following documents, of which the originals are in the archives of the Institution and of the Agricultural Department:

WASHINGTON, D. C., *January* 1, 1868.

In order to the harmonious co-operation of the Smithsonian Institution and the Department of Agriculture in their respective provinces of advancing science, they enter into the following agreement relative to the disposition of specimens:

First. All the botanical specimens in possession of the Smithsonian Institution, about twenty thousand, and all that may hereafter be collected by it, shall be transferred to the Agricultural Department on the following terms:

1. That a competent botanist, approved by the Institution, shall be appointed to have charge of the collection.

2. That the collection shall, at all times, be accessible to the public for educational purposes, and to the Institution for scientific investigation, or for supplying any information in regard to plants that its correspondents may ask for.

3. That due credit be given to the Institution in the report of the Agricultural Department for the original deposit, and for such additions as may be made to it, from time to time, by the Institution.

Second. That the Agricultural Department shall transfer to the Smithsonian Institution any specimens it may now have, or may hereafter obtain, that are not necessary to illustrate agricultural economy; such as

those of ethnology and of various branches of natural history. Similar credit to be given in this case as is required in the former.

HORACE CAPRON,
Commissioner of Agriculture.
JOSEPH HENRY,
Secretary of the Smithsonian Institution.

The following is an account of the more important additions which have been made to the collection in the Agricultural Department by the Institution since the transfer of the general herbarium in 1868:

1. A set of European plants, numbering about four hundred species, presented by Professor Paul Reintz, of Germany, in exchange, at his request, for specimens of American plants.

2. A second very extensive collection of plants from the Imperial Academy of St. Petersburg, in return for donations from the Institution. This present, like all of those we have received from the Imperial Academy, is of a most valuable character. It consists of eleven hundred species from Russia, Siberia, Western Europe, and Japan.

3. Another large collection is from the widow of the late Mr. James McMinn, Williamsport, Pennsylvania, principally of plants from the mountainous regions of Pennsylvania, but also comprising specimens from other parts of this country and different localities in Europe. Mr. McMinn was a civil engineer, and in the practice of his profession in surveying lines for railways and canals became interested in the variety of plants which were presented to his notice, and as a means of recreation, as well as of intellectual improvement, commenced the study of botany. It would appear from the examination of his herbarium, that he had entered into extensive correspondence with some of the principal botanists of this country and Europe, and had enriched his collection by exchanges. His herbarium contained about five thousand species, among which is an interesting series of plants from the Alps. The special thanks of the Institution are due to Mrs. McMinn for the judicious disposition she has made of the results of the labors of her lamented husband, which we trust will be preserved among the collections of the Government, as a permanent memorial of his devotion to science and of her enlightened liberality.

Besides the foregoing there have been added several hundred bottles of samples of agricultural materials and products, numerous specimens of seeds, roots, fibers, fungi, sections of wood, &c.

Work done in connection with the collections.—Professor Baird, during the past year, in addition to his services in regard to the exchanges, natural history, and assistance in correspondence, has completed the systematic description of the land birds of the Pacific States, forming the first volume of ornithology published, in connection with its geological survey, by the State of California. The materials for this work

were from the manuscript notes of Dr. J. G. Cooper, of San Francisco, while the descriptions are principally from specimens in the Smithsonian collections. This volume, in regard to its typography, illustrations, and the character of its contents, does honor to the liberality of the State at whose expense it was published, as well as to the science of the country. Professor Baird has also continued his labors with Dr. Brewer, of Boston, on a work relative to the general ornithology of North America; in this he has been assisted by Mr. Robert Ridgeway, the zoölogist of the exploration of the fortieth parallel under Clarence King. To the latter, free access has also been given, in the preparation of his report on the birds of Mr. King's survey, to all the ornithological specimens in the Smithsonian collections.

Mr. Meek, the palæontologist, has made a preliminary report on the fossils collected by Dr. Hayden in his survey of Wyoming and contiguous Territories, and prepared lists of the same, with descriptions of the new species. He has described and prepared drawings of a collection of cretaceous fossils, sent by Professor Mudge to the Institution, from Kansas. He has made, besides several preliminary examinations, a final report on the fossils collected by Mr. King in the survey of the fortieth parallel, with full descriptions and illustrations of all the new species. He has also investigated the invertebrate fossils collected by the geological survey of Ohio, and prepared descriptions of the new species for publication; made a preliminary report, with descriptions of some new species, on a collection of carboniferous fossils sent by Professor Stevenson from West Virginia; continued his work on the illustrations of the monograph of the palæontology of the Upper Missouri. He has also identified collections of fossils, received from time to time at the Smithsonian Institution from collectors in various parts of the country.

Mr. Dall has been engaged in collating the extensive collection of manuscript notes of the Hudson's Bay and other Arctic American collaborators with whom the institution has been in correspondence for more than fifteen years. The part of these notes which he has finished relates to ornithology, and comprises many thousand items descriptive of the habits, distribution, and numbers of the birds of the regions above referred to. These will be used by Professor Baird and Dr. Brewer in their work on the birds of North America. The manuscripts also contain notes relative to the mammals and other animals, as well as to the ethnology of the same regions. When all these are collated and published they will form an interesting contribution to existing knowledge of the natural productions and ethnology of the North American continent.

Mr. Dall has also devoted considerable time to original investigations relative to the minute anatomy of the mollusca from specimens in the collections of the Institution. His principal labor, however, has been in the rearrangement of the very large series of shells from the west coast of America and of the North Pacific, including many types of the new

species of Gould, Carpenter, Cooper, Stearns, Pease, H. and A. Adams, &c. These have mostly passed through the hands of Dr. P. P. Carpenter, of Montreal, but still required to be placed in suitable trays, and provided with new labels and specially arranged for cabinet purposes. He has also had charge throughout most of the year of the record of additions to the museum, and the labeling of collections, especially those of ethnology and osteology.

Meteorology.—The system of meteorology of the Institution has been kept up as usual during the past year. The number of observers reporting to the Institution during this period is 515, and to the Medical Department of the United States Army, to the records of which we have free access, 140. The value of these observations increases with the number of observers and the time for which the several series are continued. But observations, however long-continued and extensive, are comparatively of little value unless they are reduced and discussed; and these operations can only be performed at the expense of great labor, since thousands of figures have to be tabulated and subjected to various arithmetical processes in order to deduce the general results which constitute approximate scientific principles. As we have stated in previous reports, the discussion of the rain and temperature has been for some years in charge of Mr. Charles A. Schott. The results in regard to the rain have been printed, and will form a part of the Smithsonian Contributions for the year 1871. A general account of these results was given in the last report, but in this it may be further stated that the principal deductions are made from an original series of tables giving the monthly rain-fall from the earliest periods from all sources in the United States and adjacent countries down to 1867. From these general tables a series of consolidated tables of means for seasons and years, for the whole time, is deduced. It was thought advisable, on account of the great expense, to publish for the present the consolidated tables, and to retain the others for reference or to answer special inquiries in regard to the rain-fall of particular stations. The former have been kept up to date, all the new materials having been incorporated; and to extend the system a large number of rain-gauges have been distributed to different parts of the country, and especially to the western States.

The temperature records are still under investigation by Mr. Schott. The work was in part temporarily suspended during his absence in Europe as a member of the expedition for observing the total eclipse of last December. The following is a statement of the present condition of the discussion.

The collection of material has for the most part been completed down to the present time, and tables of hourly, bi-hourly, and semi-hourly observations of temperature have been prepared. From these have been deduced tables to be used for the correction of daily variations of temperature. The daily fluctuation of the atmospheric temperature

has been discussed, and tables giving the times of sunrise and sunset for stations between latitudes 23° and 60°, to be used for corrections of daily variation, have been computed. The annual fluctuations of temperature have been in part discussed, and the tables of maxima and minima are in an advanced state toward completion.

All the observations relative to the winds, made under the direction of the Institution, and under the Medical Department of the Army, and all those which have been collected from other sources, have been placed in charge of Professor J. H. Coffin, of Lafayette College, for reduction and discussion. It was first intended to limit the investigation to the winds of North America, but it has since been considered advisable to incorporate the whole in a memoir on the general direction of the winds of the globe. To defray the cost of the extra labor, other than that of Professor Coffin, in this investigation, an appropriation has been made from the income of the Institution. During the year, Professor Coffin has been pressing on this work, with a number of assistants, as rapidly as the means at his command and his time would allow.

The Smithsonian meteorological system was commenced in 1849, and has continued in operation until the present time. Its efforts have been directed in the line of supplementing and harmonizing other systems, of a more limited character, with that of the more general one of the Army of the United States, and in some measure with the system established in Canada. It has done good service to the cause of meteorology, 1, in inaugurating the system which has been in operation upward of twenty years; 2, in the introduction of improved instruments after discussion and experiments; 3, in preparing and publishing at its expense an extensive series of meteorological tables; 4, in reducing and discussing the meteorological material which could be obtained from all the records from the first settlement of the country till within a few years; 5, in being the first to show the practicability of telegraphic weather signals; 6, in publishing records and discussions made at its own expense, of the Arctic expeditions of Kane, Hayes, and McClintock; 7, in discussing and publishing a number of series of special records embracing periods of from twenty to fifty years in different sections of the United States, of great interest in determining secular changes of the climate; 8, in the publication of a series of memoirs on various meteorological phenomena, embracing observations and discussions of storms, tornadoes, meteors, auroras, &c.; 9, in a diffusion of a knowledge of meteorology through its extensive unpublished correspondence and its printed circulars. It has done all in this line which its limited means would permit, and has urged upon Congress the establishment, with adequate appropriation of funds, of a meteorological department under one comprehensive plan, in which the records should be sent to a central depot for reduction, discussion, and final publication.

An important step has been made toward this desirable object in the

establishment, during the last year, by Congress, of a system of practical weather reports under the direction of the War Department, with ample means for the purchase standard instruments, the pay of assistants, and telegraphic dispatches. The results of this system in the way of prediction have been eminently successful, and have everywhere met with popular favor. The organization and administration of the system by General Myer, the director, has evinced great executive ability, and his wisdom has been shown in selecting Professor Abbe as his scientific assistant. It should be recollected, however, that the principles employed in foretelling the weather are practical results previously arrived at by the investigations of men of abstract science founded on simultaneous records without the aid of telegraphic communication. For the discovery of the general laws of meteorological phenomena, simultaneous observations should be made over large portions of the earth, and the records of these collected at stated periods, say at the end of every month, at some central office, and submitted first to preliminary reduction, and finally to the critical study of men like Espy, Redfield, and others, fitted by education, experience, and mental peculiarities to deduce from them the required generalizations. I would therefore suggest that a still larger appropriation be made by Congress to the War Department for establishing, besides the reports for weather signals, a series of intermediate stations, also furnished with compared instruments, to record daily observations to be transmitted to Washington weekly or monthly, and also that provision be made for the support of a number of competent persons to carry on the reductions and prepare the results for publication.

It has been the policy of this Institution from the first to do nothing which can be done as well or better by other means, and in accordance with this policy the Institution would willingly relinquish the field of meteorology, which it has so long endeavored, though imperfectly, to cultivate, turning over to the Signal Office all the material which it has accumulated up to a given epoch. We would advise also a similar course to be pursued on the part of the Medical Department of the Army. All the deductions from the combined materials which have been collected up to the present time should be obtained and published although since, they may be in many respects defective, they contain the essential element of long periods of meteorological changes and a new era commence with more precise instruments and improved methods of observation. From such a system, however perfect it may be, immediate results are not to be expected. New and important deductions can scarcely be obtained until after a continuance of the system for several years, as, for example, the accurate determination of the periodicity which probably exists in regard to the droughts of the western coast.

Before closing this report it is proper that I should refer to a resolu-on adopted by your honorable board at its last session, granting me ;ave of absence to visit Europe to confer with savans and societies ;lative to the Institution, and making provision for the payment of my xpenses. The presentation of this proposition was entirely without ıy knowledge, but I need scarcely say that its unanimous adoption was ighly gratifying to my feelings, and that I availed myself of the privi-;ge it offered with a grateful appreciation of the kindness intended.

I sailed from New York on the 1st of June, returning, after an absence f four and a half months, much improved in health and with impres-ions, as to science and education in the Old World, which may be of alue in directing the affairs of the Institution. Although limited as to ime, and my plans interfered with somewhat by the war, I visited ;ngland, Ireland, Scotland, Belgium, parts of Germany and France. ;ut deferring, for the present, an account of my travels and the observa-ions connected with them, I will merely state that, as your representa-ive, I was everywhere kindly received, and highly gratified with the ;ommendations bestowed on the character and operations of the nstitution intrusted to your care.

Respectfully submitted.

JOSEPH HENRY.

JANUARY, 1871.

APPENDIX TO THE REPORT OF THE SECRETARY.

Table showing the entries in the record-books of the Smithsonian Museum in 1869 and 1870.

Class.	1869.	1870.
Skeletons and skulls	9,708	11,512
Mammals	9,516	9,773
Birds	58,976	61,150
Reptiles	7,517	7,535
Fishes	7,885	7,897
Eggs of birds	15,500	15,671
Crustaceans	1,287	1,287
Mollusks	21,770	22,345
Radiates	2,725	2,730
Annelids	100	100
Fossils	7,283	7,350
Minerals	6,977	7,154
Ethnological specimens	9,233	10,000
Plants	175	175
Total	158,652	164,709

Total entries during the year 6,057

Of the above enumeration, 4,154 specimens of the birds and 500 of the mammals are mounted and on exhibition in the hall.

Approximate table of distribution of duplicate specimens to the end of 1870.

Class.	Distribution to the end of 1869.		Distribution in 1870.		Total.	
	Species.	Specimens.	Species.	Specimens.	Species.	Specimens.
Skeletons and skulls	154	593	60	78	214	67[illegible]
Mammals	885	1,706	31	76	916	1,7[illegible]
Birds	12,951	18,996	2,200	3,564	34,951	22,5[illegible]
Reptiles	1,701	2,830	40	40	1,741	2,87[illegible]
Fishes	2,434	5,210	1	1	2,435	5,21[illegible]
Eggs of birds	4,381	11,711	2,074	4,683	6,455	16,39[illegible]
Shells	78,391	177,927	3,087	5,230	81,178	183,15[illegible]
Radiates	551	727	32	51	583	77[illegible]
Crustaceans	1,023	2,526	55	124	1,078	2,650
Marine invertebrates	1,838	5,152	.....	.....	1,838	5,152
Plants and packages of seeds	13,658	19,218	1,845	1,845	15,503	21,063
Fossils	3,958	9,984	.....	.....	3,958	9,984
Minerals and rocks	2,880	7,774	750	800	3,630	8,574
Ethnological specimens	1,107	1,154	36	36	1,143	1,190
Insects	1,532	2,846	100	100	1,632	2,946
Diatomaceous earths	26	566	2	2	28	568
Total	127,470	268,920	10,313	16,630	127,783	285,520

ADDITIONS TO THE COLLECTIONS OF THE SMITHSONIAN INSTITUTION IN 1870.

Adams, F. C.—Limestone rock, Virginia.

Agricultural Department United States, Hon. Horace Capron, Commissioner.—Skin of monkey and parrot, South America; reptiles in alcohol, from Colorado, California, and the East Indies; dry fish and crustacea from China and New York Harbor. (See elsewhere under other entries.)

Aiken, E. C.—Skins of *Leucosticte tephrocotis*, Rocky Mountains.

Albuquerque, Don Frederico.—Barrel of fish in alcohol, from Brazilian rivers.

Alden, Dr. C. H., United States Army, through the Army Medical Museum.—Petrified wood, fossils and minerals, from Colorado Territory.

Anderson, General, through J. M. Thompson.—Fresh heads, hoofs and skins of the American bison, Kansas.

Army Medical Museum, United States; Dr. George A. Otis, United States Army, in charge.—Stone implements from Colorado Territory; fossil teeth of mastodon, &c., Alabama. (See also under the names of the medical officers United States Army.)

Baird, Professor S. F.—Carvings of northeastern Eskimo; arrow-heads, relics from ancient shell-heaps on the coast of Massachusetts; fish and turtles in alcohol, fin of thresher shark, jaws and skeletons of fish, from Wood's Hole, Massachusetts.

Bannister, H. M.—Arrow-heads, &c., Illinois.

Baurmeister, Rev. W.—Minerals, Indiana.

Balbach, A.—Fœtal mice in alcohol, New Jersey.

Baldwin, Charles S.—Archæological specimens, Tennessee.

Barker, T. S.—Shell adze and arrow-heads, Florida.

Bentley, Dr. E., Assistant Surgeon United States Army, through Army Medical Museum.—Stone implements, San Francisco Bay, California.

Berendt, Dr.—Turtles, fossil fish and plants, from Mexico.

Berthoud, Captain E. L.—Flint-flakes and scrapers, Colorado Territory.

Bishop, N. H.—Cuban mocking-birds in alcohol.

Blackmore, William.—Model of Stonehenge and flint implements, Great Britain.

Boardman, George A.—Bird skins, nests, and eggs, from Maine and Florida; models of great auk egg, skulls of buffalo and gnu, South Africa.

Bolander, Dr. H.—Californian seeds.

Boucard, A.—Bird skins from Mexico.

Bowman, J. B.—Collection of birds, and one mammal, from Australia.

Brevoort, J. Carson.—Bones of the dodo, from Mauritius.

Brown, Solomon G.—Arrow-heads, District of Columbia.

Bryan, O. N.—Pottery, stone implements, arrow-heads, &c., Virginia.

Bryant, Captain Charles.—Skins of the walrus and seal, from Alaska.

Burn, J. P.—Specimens of rock from the Bosphorus.

Burr, Fearing—Specimens from Massachusetts shell-heaps.

Burrough, J.—Nest and skin of mourning warbler, New York.

Cameron, John.—Mask from an Egyptian sarcophagus.

Central Park Commissioners, New York.—Cast of antique statue, Costa Rica.

Chase, Thomas.—Stone mortar and pestle, Virginia.

Coleman, N.—Insects from Ohio.

Collins, H.—Specimens from shell-heaps, Louisiana.

Condon, Rev. Thomas.—Fossils from Columbia River.

Cooper, Theodore.—Shells from the Galapagos Islands.

Coues, Dr. Elliott, United States Army.—Bird-skins from North Carolina.

Curtis, Dr. Josiah.—Indian implements, pottery, &c., from Tennessee and Georgia.

Dall, Rev. C. H. A.—Skull and horns of the buffalo of southern India.

Dall, W. H.—Specimens of mollusca and shells from various localities.

Damon, R.—Specimens of brachiopods from the European seas.

Dant, Thomas E.—Abnormal eggs of domestic fowl.

Davis, Henry.—Fossils from Iowa.

Day, Robert, jr.—Stone implements from Ireland.

Domeyko, Professor, University of Chili.—Chilian minerals.

Dow, Captain J. M.—Skulls and bones of tapirs from Central America; young tapir in alcohol, and other alcoholic specimens, from Panama.

Durkee, H. R.—Human remains and fossils from Wyoming Territory; birds, eggs, and nests, with some osteological specimens, from the same locality.

Evans, Abner G., by the Hon. W. Townsend.—Stone implements from Pennsylvania.

Finck, Hugo.—Stone antiquities from Mexico.

Fitzgerald, Dr. J. A., United States Army, (by Dr. J. S. Billings, United States Army.)—Fossil teeth from Indian Territory.

Flügel, Dr. Felix.—Alcoholic specimens, Europe.

Foreman, Dr. E.—Fresh-water shells, District of Columbia.

Gardner, G. T.—Specimens from Maine shell heaps.

Gibbs, Mr.—Box seeds, nuts, &c., Kansas.

Girard, Dr. Basil, United States Army, (through Army Medical Museum.)—Fossils from Wyoming Territory.

Gleason, W. T.—Glaciated rock, Connecticut.

Glover, Lieutenant Russell, United States Revenue Marine.—Specimens of *Acmæa testudinalis* and *Boltenia clavata* from the coast of Maine.

Graves, E. D.—Lignite, Pennsylvania.

Graves, W. W.—Infusorial earth from Maine.

Guest, Follis, (through Hon. W. Townsend.)—Stone implements, Pennsylvania.

Hachenburg, Dr.—Scale of sturgeon.

Hall, George E.—Specimens of grinding and building stone, Ohio.

Hall, John.—Indian crania and bones, San Francisco.

Haney, Jesse H.—Indian silver ornament, Arkansas.

Hanson, Walter.—Stone awl, Missouri. Apache basket from New Mexico.

Hartman, Dr.—Collection of insects, Pennsylvania.

Haskins, Mr.—Horned toad, California.

Hayden, Dr. F. V.—Beaver cuttings from the Rocky Mountains. (See also United States Geological Survey of Territory.

Heaton, L. D., (through Agricultural Department.)—Reptile from Texas.

Henriques, Captain United States Revenue Marine.—Ethnological and botanical collections from Alaska.

Himes, Professor C. F.—Bones from the Carlisle bone-cave, Pennsylvania.

Hinckley, J. R.—Fish and fishbones, Massachusetts coast.

Hoover, H.—Fossils and arrow-heads, Pennsylvania.

Hoxie, Walter.—Eggs of *Cathartes atratus*, South Carolina.

Hoy, Dr. P. R.—Fish, &c., from deep dredgings off Racine, Wisconsin.

Hutchinson, Kohl & Co.—Seal-skins, walrus skull and volcanic sand, Alaska.

Jackson, Haliday, (through Hon. W. Townsend.)—Stone implements, Pennsylvania.

Jackson, R. S.—Osteological and oölogical specimens from Louisiana.

Johnson, Eugene.—Indian redstone pipe.

Johnson, Lieutenant.—Specimen of an owl, District of Columbia.

Jones, Rev. C. M.—Nests of *Ammodromus maritimus* and *candacutus*, Connecticut.

Jones, Jno. P.—Cranium of mound builder, Missouri.

Jones, Strachan, Hudson Bay Company.—Collection of birds and eggs, Little Slave Lake, Hudson Bay territory.

Keenan, T. J. R.—Unionidæ, specimens of ethnology and natural history from Mississippi. Two specimens of continental currency.

Kellogg, Dr. A.—Plants from California.

King, Clarence.—Stone pestle, California. Minerals and rocks from Nevada.

Knapp, Dr. James.—Collection of fossils, Kentucky.

Knight, Jeremiah.—Plate of crystallized quartz from Orange County, New York.

Kohler, Mr.—Seventy pound mass of silicate of zinc, Union Lead Works, Virginia.

Lancaster, Dr.—Mineral residue from water of Alum Springs, Virginia.

Lartet, Professor E.—Bone breccia from the bone-caves of Dordogne, France.

Latham, General G. R.—Skin of kangaroo, Australia.

Latimer, George.—Collection of birds, Porto Rico.

Laming, Dr. F.—Stone implements, Indiana.

Lewis, Dr. James—Fresh-water shells, Mohawk River, New York.

Limpert, W. R.—Nests and eggs, Ohio.

Lincecum, Dr. G.—Alcoholic mammals and reptiles, Mexico.

Linden, Charles.—Three bird-skins, New York.

Lockhart, James, Hudson Bay Company.—Birds and eggs, Fort Yukon, Alaska.

Long, Owen, M., United States Consul.—Fish from Panama.

Luddington, Colonel United States Army.—Carvings from the Old Pecos Church, New Mexico.

Lupton, Professor N. T.—Indian stone relics, Warrior River, Alabama.

McElderry, Dr. H., United States Army, (through the Army Medical Museum.)—Fossils from Texas.

Macfarlane, R., Hudson Bay Company.—Birds and eggs from the Anderson River, Hudson Bay territory, being the collections for 1866.

McIlvaine, J. A.—Indian pottery from Pennsylvania.

McIlvaine, J. H.—Birds from Central America.

McLain, R. T., United States Agricultural Department.—Indian stone implements from Maryland.

Madras, Government Museum.—Skeleton of hyena, and collection of East Indian birds.

March, William, (by Agricultural Department.)—Stone knives, Ohio.

Martin H.—Eggs of *Ectopistes migratoria*, from Michigan.

Mathews, Dr. W., United States Army.—Bull-boat used by Indians of the Indian Territory, wooden mortar, matting, head of antelope with deformed horns; ethnological specimens; same locality.

Mechling, Mrs. F. E. D., (through Agricultural Department.)—Reptiles from Belize.

Merritt, E. S.—Indian arrow-heads, Long Island.

Merritt, J. C.—Arrow-heads from Long Island.

Meulen, Lieutenant E. de, United States Army.—Plants from Cook's Inlet, Alaska.

Miller, Dr. George, United States Army.—Bird's eggs, Colorado Territory.

Milne, Edwards, Professor Alphonse.—Casts of *Æpyornis* bones and fossil birds of France.

Minor, Dr. T. T., United States Army.—Indian crania from Vancouver's Island.

Moore, Carlton R.—Fish and corals from the coast of Virginia.

Moore, James H.—Sulphate of strontia, Virginia.

Moore, N. B.—Mounted tree-duck, Louisiana.

Nantucket Athenæum.—Skull of killer whale.

New Albany Society of Natural History.—Cast of a copper spear-head from the mounds, Indiana.

Newman, Jos., (by Agricultural Department.)—Stone implements from South Carolina.

New Zealand Colonial Museum.—Bones of *Dinornis*, and *Apteryx*, shells, bird-skins, and ethnological specimens from New Zealand.

Nickerson, George Y.—Antique soapstone inkstand, Cape Cod.

Northwestern University.—Fossils and skins of gar pike from Illinois.

Orton, Professor James.—Tertiary fossils from the Amazon.

Palmer, Dr. E., (partly through the Agricultural Department.)—Large and varied collections of specimens in various departments of zoölogy, botany, ethnology, and archæology from Arizona, Utah, and New Mexico.

Passmore Lewis, (by the Hon. W. Townsend.)—Stone implements, Pennsylvania.

Pease, Horatio N.—Tooth of fossil cetacean, Gay Head, Massachusetts.

Pim, Geo. E., (by Hon. W. Townsend.)—Stone implements, Pennsylvania.

Platt, L. W.—Indian clothing and ornaments, Nebraska.

Pourtales, L. F. de.—Marine invertebrates from Florida.

Price, J. D.—Crystallized calcite, Virginia.

Quatrefages, Professor.—Casts of osteological and other specimens from the caves of Cromagnon, France.

Rankin, Mr.—Indian crania, Massachusetts coast.

Ransom, Governor, (through Mr. Thos. Bland.)—Land shells from Barbadoes.

Reed, Byron.—Ortyx Virginianus, Nebraska.

Ricksecker, L. E.—Birds' eggs, Pennsylvania.

Ridgeway, Robert.—Birds from Illinois.

Ring, Lieut. F. M., United States Army.—Collections of birds, osteological specimens, ethnology, archæology, &c., from Alaska.

Sacho, H.—Saturnia rubescens from Chili.

St. Petersburg Imperial Botanic Garden.—Russian, Siberian, Japanese, and other plants.

Salvin, O.—Birds from the Falkland Islands.

Scammon, Capt. C. M., U. S. Revenue Marine.—Baleen of Pacific sulphurbottom whale.

Schott, Dr. A.—Crystals of rock-salt, Texas.

Sclater, Dr. P. L.—Birds from Peruvian Andes and Buenos Ayres.

Sessions, Luther.—Birds' eggs, Connecticut.

Sharpless, P. P., (through Hon. W. Townsend.)—Stone implements from Pennsylvania.

Sherwood, Andrew.—Devonian fish remains from Pennsylvania.

Sibbeston, J., Hudson Bay Company.—Birds and eggs, Fort Yukon, Alaska.

Spinner, General F. E.—Fresh specimen of the copperhead snake, District of Columbia.

Stearns, R. E. C.—Pottery vase and beads from Chiriqui, Central America.

Stelle, J. P.—Archæological and ethnological specimens from Tennessee mounds.

Sternberg, C. H. and Dr. G. M.—Fossil plants from Kansas.

Stevenson, J.—Mounted *Neotoma*, Wyoming Territory.

Stevenson, J. J.—Stone implements, West Virginia.

Stiles, Hon. Jno. D., M. C.—Specimen of iridescent hematite.

Streng, L. H.—Miscellaneous shells.

Stuart, Mrs. R. L.—Stone pipe, Virginia.

Sumichrast, Dr. Francis—Miscellaneous zoölogical collections, Isthmus of Tehuantepec.

Thomas, Ezra, (through Hon. W. Townsend.)—Stone implements, Pennsylvania.

Thompson, R. O.—Fossils and birds' skins from Missouri.

Thomson, J. H.—Eggs of African ostrich, and of *Casuarius Bennettii* or "mooruk" from New Britain, and rocks containing garnets from New Bedford.

Tolman, J. W.—Birds' eggs, Illinois.

Townsend, Hon. W.—Stone implements from Pennsylvania. (See also under other entries.)

Turner, G.—Flint implements, Illinois.

United States Geological Survey of the Territories.—Dr. F. V. Hayden in charge. Large miscellaneous zoölogical and paleontological collections from the Rocky Mountains.

Unknown.—Stone ax, Missouri? Stone implements and fossil corals, Canada? Box fossils, Missouri? Skeleton Pottawattomie Indian?

Vickary, Dr. R. S., Assistant Surgeon, United States Army.—Arrow-heads and pottery, New Mexico.

Vienna, Imperial Zoölogical Museum of.—Birds and skin and skeleton of the aurochs, from Austria.

Verrill, Professor A. E.—Miscellaneous radiates.

Wachsmuth, Chas.—Fossil crinoids, Iowa.

Walker, Dr. Robert L., (through Agricultural Department.)—Arrow-heads from Virginia.

Weile, Chas., United States Consul.—Reptiles from Guayaquil.

Weinland, Dr. D. F.—Land-shells from the Bahama and West Indian Islands.

Wiggins, William.—Crystallized cinnabar in quartz, California.

Williams, General A. D., (through Captain J. M. Dow.)—Pottery from San Salvador, Central America.

Williams, Dr. H. C.—Arrow-heads, Virginia, and stone implements from the same locality.

Willmuth, J. A. H.—Mounted agouti, (*Dasyprocta*,) South America, through Agricultural Department.

Wilson, Jas.—Stone implements (through the Hon. W. Townsend) from Pennsylvania.

Wilson, Dr. S. W.—Five amphiumas from Georgia.

Witter, David K.—Fossils and seeds, Iowa.

Yager, W. E.—Nest of *Tyrannus Carolinensis*, New York.

Yates, Dr. L. S.—Indian crania from mounds and stone mortar with pestle from California.

LITERARY AND SCIENTIFIC EXCHANGES.

Table showing the statistics of the Smithsonian exchanges in 1870.

Agent and country.	Number of addresses.	Number of packages.	Number of boxes.	Bulk of boxes in cubic feet.	Weight of boxes in pounds.
Dr. FELIX FLÜGEL, *Leipsic:*					
Russia	84	92	.....	.....	.....
Germany	436	486	.....	.....	.....
Switzerland	51	60	.....	.....	.....
Greece	6	6	.....	.....	.....
Total	577	644	51	539	13,291
ROYAL SWEDISH ACADEMY OF SCIENCES, *Stockholm:*					
General	4	4	.....	.....	.....
Sweden	17	41	.....	.....	.....
Total	21	45	3	30	729
ROYAL UNIVERSITY OF NORWAY, *Christiania:*					
Norway	11	17	2	20	486
ROYAL DANISH SOCIETY OF SCIENCES, *Copenhagen:*					
Denmark	23	28	.....	.....	.....
Iceland	1	1	.....	.....	.....
Total	24	29	3	30	729
FREDERICK MÜLLER, *Amsterdam:*					
Holland	57	62	.....	.....	.....
Belgium	33	36	.....	.....	.....
Total	90	98	6	60	1,458
GUSTAVE BOSSANGE, *Paris:*					
France	165	176	.....	.....	.....
Spain	9	11	.....	.....	.....
Portugal	2	6	.....	.....	.....
Algeria	2	2	.....	.....	.....
Total	178	195	13	123	4,032
ISTITUTO LOMB. DI SCIENCE E LETTERE, *Milan:*					
Italy	136	144	8	80	1,944
WILLIAM WESLEY, *London:*					
Great Britain and Ireland	268	494	.....	.....	.....
Cape Town, Africa	3	3	.....	.....	.....
Total	271	314	20	195	5,879
Rest of the world	119	136	15	112	2,835
Grand total	1,425	1,805	121	1,189	31,383

Packages received by the Smithsonian Institution from parties in America, for foreign distribution, in 1870.

Address.	No. of packages.
ALBANY, NEW YORK.	
Albany Institute	12
Dudley Observatory	35
New York State Library	53
New York State Agricultural Society	12
New York State Homeopathic Society	17
New York State Medical Society	30
Dr. Paine	2
ANN ARBOR, MICHIGAN.	
University of Michigan	2
BOSTON, MASSACHUSETTS.	
American Academy of Arts and Sciences	263
Board of State Charities	74
Boston Society of Natural History	341
Bureau of Statistics of Labor	12
Public Library	16
Dr. T. M. Brewer	1
Dr. B. A. Gould	10
Dr. Howe, (Perkins Institute for Blind)	29
CAMBRIDGE, MASSACHUSETTS.	
Cambridge Observatory	3
American Association for Advancement of Science	8
Harvard College	68
Museum of Comparative Zoölogy	258
Professor Asa Gray	1
CHARLESTON, SOUTH CAROLINA.	
Dr. F. P. Porcher	2
CHICAGO, ILLINOIS.	
Academy of Sciences	50
Chicago Medical Times	11
CINCINNATI, OHIO.	
Observatory	36
COALBURG, WEST VIRGINIA.	
W. H. Edwards	4
COLUMBUS, OHIO.	
Ohio State Agricultural Society	89
DORCHESTER, MASSACHUSETTS.	
Dr. Edward Jarvis	30
EASTON, PENNSYLVANIA.	
Professor T. C. Porter	2
GEORGETOWN, D. C.	
Dr. A. Schott	1
HAVANA, CUBA.	
Professor F. Poey	2
INDIANAPOLIS, INDIANA.	
Institution for Deaf and Dumb	20
Institution for Education of Blind	100
State Geological Survey	400
IOWA CITY, IOWA.	
Grand Lodge of Iowa	2
Iowa Institution for Deaf and Dumb	23
Professor Hinrichs	104
JEFFERSONVILLE, INDIANA.	
S. S. Lyon	1
MEXICO.	
Mex. Soc. Mex. de Hist. Natural	2
MONTREAL, CANADA.	
Professor P. P. Carpenter	
NEW BEDFORD, MASSACHUSETTS.	
J. H. Thomson	
NEW HAVEN, CONNECTICUT.	
American Journal of Science	2
Connecticut Academy of Sciences	1
Professor A. E. Verrill	
NEW YORK.	
American Institute	1
New York Lyceum of Natural History	1
American Christian Commission	
H. Maunsell Schieffelin	5
PHILADELPHIA, PENNSYLVANIA.	
Academy of Natural Sciences	2
American Philosophical Society	71
Franklin Institute	

Packages received from parties in America, &c.—Continued.

Address.	No. of packages.
ILADELPHIA, PA.—Continued.	
rd College	1
orical Society of Pennsylvania	19
ısylvania House of Refuge	25
ısylvania Institute for Deaf and umb	25
ety for Alleviation of Miseries Public Prisons	25
ıner Free Institute of Science	113
Isaac Lea	36
G. H. Horn	3
'eale	1
HŒNIXVILLE, PENNSYLVANIA.	
I. Wheatley	2
PORTLAND, MAINE.	
ıral History Society	65
PRINCETON, NEW JERSEY.	
Stockton	3
ROVIDENCE, RHODE ISLAND.	
C. M. Snow	26
SALEM, MASSACHUSETTS.	
ε Institute	165
ody Academy of Science	71
ı. S. Packard	16
. Putnam	1
ST. PAUL, MINNESOTA.	
ıesota Historical Society	22
SOUTH HANOVER, INDIANA.	
. Bradley	2
SPRINGFIELD, ILLINOIS.	
Professor A. H. Worthen	4
WASHINGTON, D. C.	
Bureau of Navigation	1
Bureau of Statistics	100
Columbia Institute for Deaf and Dumb	160
Medical Department United States Army	16
Nautical Almanac Office	94
Treasury Department	18
United States Coast Survey	200
United States Agricultural Department	472
United States Naval Observatory	169
United States Patent Office	14
William H. Dall	30
Dr. F. V. Hayden	68
General J. A. Garfield	60
T. Pœsche	2
B. P. Poore	39
WILMINGTON, DELAWARE.	
W. M. Canby	2
WINNEBAGO, ILLINOIS.	
M. S. Bebb	2
ADDRESSES UNKNOWN.	
F. N. Hasselquist	1
A. Zeno Shindler	200
G. M. Levette	1
Unknown	20
Total	6,481

Packages received by the Smithsonian Institution from Europe, in 1870, for distribution in America.

Address.	No. of packages.
ALBANY, NEW YORK.	
Albany Institute	6
Dudley Observatory	20
New York State Agricultural Society	31
New York State Library	27
New York State Medical Society	1
New York State University	5
State Cabinet of Natural History	6
Governor of the State of New York	1
Hon. Francis C. Barlow	1
Professor James Hall	24
Dr. Woolworth	1
AMHERST, MASSACHUSETTS.	
Amherst College	4
Professor C. U. Shepard	2
ANNAPOLIS, MARYLAND.	
St. John's College	1
State Library	1
United States Naval Academy	1
ANN ARBOR, MICHIGAN.	
Observatory	12
University of Michigan	1
Major T. D. Brooks	2
Professor A. Winchell	9
APPLETON, WISCONSIN.	
Lawrence University	1
AUSTIN, TEXAS.	
State Library	2
Texas Institution for Deaf and Dumb	1
BALTIMORE, MARYLAND.	
Maryland Historical Society	7
Peabody Institute	2
S. C. Chew	1
Rev. Edwin Dalrymple	1
Dr. E. Foreman	1
Martin Lewis	1
N. H. Morrison	1
Dr. P. R. Uhler	1
BANGOR, MAINE.	
Dr. A. C. Hamlin	2
BATON ROUGE, LOUISIANA.	
Louisiana Institution for Deaf and Dumb	1
BETHLEHEM, PENNSYLVANIA.	
Lehigh University	3
BINGHAMTON, NEW YORK.	
Institution for Blind	1
BLOOMINGTON, ILLINOIS.	
Illinois Natural History Society	1
BOSTON, MASSACHUSETTS.	
American Academy of Arts and Sciences	131
American Christian Examiner	1
American Statistical Association	6
American Unitarian Association	2
Athenæum	1
Board of State Charities	1
Boston Christian Register	1
Boston Society of Natural History	195
Massachusetts Historical Society	9
New England Historico-Genealogical Society	3
North American Review	7
Prison Discipline Society	2
Public Library	23
State Library	7
Rev. W. R. Alger	3
N. Apollonio	1
Rev. Caleb D. Bradlee	1
Dr. T. M. Brewer	3
Mellen Chamberlain	1
Professor D. Cheever	1
Samuel G. Drake	1
Rev. Dr. Garnett	1
W. Lloyd Garrison	1
Dr. S. G. Howe	2
Gardiner G. Hubbard	1
Alpheus Hyatt	1
J. Norton	1
Francis Parkman	2
Captain P. W. Penhallow	1
Wendell Phillips	1
A. P. Rockwell	5
Professor W. B. Rogers	1
S. H. Scudder	4
J. A. Swan	1
Walker, Fuller & Co	7
Dr. T. H. Webb	1
Henry C. Wright	1
BROOKLINE, MASSACHUSETTS.	
Colonel T. Aspinwall	1
Professor T. Lyman	4
BROOKLYN, NEW YORK.	
Long Island Historical Society	1

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
, NEW YORK—Continued.	
thelmes	1
. Beecher	1
Brevoort	1
Murphy	1
Smith	1
RUNSWICK, MAINE.	
College	3
Society of Maine	3
FFALO, NEW YORK.	
istorical Society	2
RLINGTON, IOWA.	
röm	1
uth	1
NGTON, NEW JERSEY.	
ney	3
LINGTON, VERMONT.	
	1
of Vermont	3
DGE, MASSACHUSETTS.	
Association for Advance-Science	41
cal Journal	2
College	28
n of Harvard College	2
f Comparative Zoölogy	37
ry of Harvard College	34
Agassiz	1
L. Agassiz	56
Asa Gray	18
J. G. Anthony	1
Gould	8
gen	3
ter	1
B. Peirce	4
	1
Perry	1
ick	8
achner	1
J. D. Whitney	5
J. Winlock	3
J. Wyman	2
NTON, NEW YORK.	
nce University	1
ISLE, PENNSYLVANIA.	
College	2
Literature	2
CAVE SPRING, GEORGIA.	
Georgia Institution for Deaf and Dumb	1
CHAPEL HILL, TEXAS.	
Soulé University	3
CHARLESTON, SOUTH CAROLINA.	
Charleston Museum	1
Elliott Society of Natural History	16
Society Library	2
South Carolina Historical Society	3
Dr. John E. Holbrook	1
CHARLESTOWN, NEW HAMPSHIRE.	
Dr. S. Webber	1
CHARLOTTESVILLE, VIRGINIA.	
University of Virginia	4
CHICAGO, ILLINOIS.	
Chicago Academy of Sciences	59
Chicago College of Pharmacy	1
Board of Trade	3
Dearborn Observatory	8
Historical Society of Chicago	1
Insane Asylum	1
Medical Times	2
Andrew Bolter	1
S. A. Briggs	1
M. De la Fourtrie	1
T. H. Safford	2
Charles Sonnes	1
Dr. W. Stimpson	7
CINCINNATI, OHIO.	
American Freemason	1
American Medical College	1
Astronomical Observatory	21
Historical and Philosophical Society	2
Mercantile Library Association	1
City Clerk	1
Dr. Cleveland Abbe	1
J. G. Anthony	1
Daniel Vaughan	1
CLINTON, NEW YORK.	
Observatory of Hamilton College	3
Dr. C. H. F. Peters	3
COALBURGH, WEST VIRGINIA.	
W. H. Edwards	1

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
COLUMBIA, MISSOURI.	
Geological Survey of Missouri	2
University of Missouri	2
Dr. G. C. Swallow	1
COLUMBIA, SOUTH CAROLINA.	
South Carolina College	2
State Library	1
COLUMBUS, OHIO.	
Institution for Deaf and Dumb	1
Ohio State Board of Agriculture	53
Leo Lesquereux	4
CONCORD, NEW HAMPSHIRE.	
New Hampshire Historical Society	4
State Lunatic Asylum	1
COUNCIL BLUFFS, IOWA.	
Iowa Institution for Deaf and Dumb	1
DANVILLE, KENTUCKY.	
Kentucky Institution for Deaf and Dumb	1
DECORAH, IOWA.	
Norwegian Luther College	3
DELAWARE, OHIO.	
Ohio Wesleyan University	1
DELAVAN, WISCONSIN.	
Wisconsin Institution for Deaf and Dumb	1
DES MOINES, IOWA.	
Geological survey of Iowa	1
Governor of the State of Iowa	1
State Library	6
DETROIT, MICHIGAN.	
Michigan State Agricultural Society	8
DORCHESTER, MASSACHUSETTS.	
Dr. Edward Jarvis	12
DURHAM CENTRE, CONNECTICUT.	
Rev. W. Fowler	1
EAST GREENWICH, NEW YORK.	
Asa Fitch	1
EASTON, PENNSYLVANIA.	
Lafayette College	3
Professor T. C. Porter	1
EVANSTON, ILLINOIS.	
Northwestern University	2
FAIRIBAULT, MINNESOTA.	
Minnesota Institution for Deaf and Dumb	1
FALL RIVER, MASSACHUSETTS.	
Niel Arntzen	1
FLINT, MICHIGAN.	
Michigan. Asylum for Deaf and Dumb	1
FORT MACON, NORTH CAROLINA.	
Dr. E. Coues	1
FRANKFORT, KENTUCKY.	
Geological Survey of Kentucky	4
FREDERICK, MARYLAND.	
Maryland Institution for Deaf and Dumb	1
FREDERICKTON, NEW BRUNSWICK.	
King's College	1
Legislative Library	1
FULTON, MISSOURI.	
Missouri Asylum for Deaf and Dumb	1
GALESBURG, ILLINOIS.	
Lombard University	1
GALESVILLE, WISCONSIN.	
Galesville University	1
GAMBIER, OHIO.	
Kenyon College	2

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
ENEVA, NEW YORK.	
H. L. Smith	1
EORGETOWN, D. C.	
vn College	4
ND RAPIDS, MICHIGAN.	
rier	1
ENCASTLE, INDIANA.	
sbury University	1
LIFAX, NOVA SCOTIA.	
tian Institute of Natural s	2
George Lawson	1
MILTON, NEW YORK.	
University	1
. Kendrick	1
DEN SYDNEY, VIRGINIA.	
Sydney College	1
VER, NEW HAMPSHIRE.	
h College	4
HAVANA, CUBA.	
F. Poey	2
SBURG, PENNSYLVANIA.	
ociety of the State of Penn- a	2
rary	2
TFORD, CONNECTICUT.	
Asylum for Deaf and	1
l Society of Connecticut	2
ylum	1
en's Institute	1
ollege	1
HUDSON, OHIO.	
Reserve College	1
DIANAPOLIS, INDIANA.	
Historical Society	3
INDIANAPOLIS, IND.—Continued.	
Indiana Institute for Blind	2
Indiana Institution for Deaf and Dumb	1
Dr. W. W. Butterfield	1
INMANSVILLE, WISCONSIN.	
Wisconsin Scandinavian Society	1
IOWA CITY, IOWA.	
Grand Lodge	1
Iowa State University	21
Professor G. Hinrichs	1
Dr. C. A. White	1
ITHACA, NEW YORK.	
Cornell College	3
Dr. Wesley Newcomb	1
Professor Goldwin Smith	1
JACKSON, MISSISSIPPI.	
State Library	1
J. S. B. Thacker	1
JACKSONVILLE, ILLINOIS.	
Illinois Institute for Blind	1
Illinois Institution for Deaf and Dumb	1
JEFFERSON CITY, MISSOURI.	
Historical and Philosophical Society	2
KEYTESVILLE, MISSOURI.	
Charles Veatch	2
KINGSTON, CANADA.	
Botanical Society of Canada	2
Queen's College	1
KNOXVILLE, TENNESSEE.	
Tennessee School for Deaf and Dumb	1
LEBANON, TENNESSEE.	
Cumberland University	1
LEWISBURG, PENNSYLVANIA.	
University	1
LEXINGTON, KENTUCKY.	
Rev. T. W. Coit	1

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
LEXINGTON, VIRGINIA.	
M. F. Maury	4
LITTLE ROCK, ARKANSAS.	
Arkansas Institution for Deaf and Dumb	1
State Library	15
State University	2
LOUISVILLE, KENTUCKY.	
City Clerk	1
Grand Lodge	1
University of Louisville	2
Historical Society of Kentucky	1
LYNN, MASSACHUSETTS.	
Massachusetts Society of Natural History	1
MADISON, WISCONSIN.	
Emigranten	1
Historical Society of Wisconsin	5
State Library	1
Wisconsin State Agricultural Society	16
Dr. P. A. Chadbourne	1
Mr. Hill	1
MIDDLETOWN, CONNECTICUT.	
Wesleyan University	1
MILLEDGEVILLE, GEORGIA.	
State Library	1
University	1
MILWAUKEE, WISCONSIN.	
Increase A. Lapham	1
MONTGOMERY, ALABAMA.	
State Library	1
MONTPELIER, VERMONT.	
Historical and Antiquarian Society of Vermont	3
State Library	4
Dr. Albert Hager	1
MONTREAL, CANADA.	
Geological Survey of Canada	7
McGill College	2
Montreal Historical Society	1
MONTREAL, CANADA—Continued.	
Natural History Society	35
Observatory	2
E. Billings	3
Professor P. P. Carpenter	1
Professor J. W. Dawson	9
Professor J. Sterry Hunt	1
Sir William Logan	8
NASHVILLE, TENNESSEE.	
State Library	1
University of Nashville	1
Rev. Philip Lindsley	1
NATCHEZ, MISSISSIPPI.	
William P. Miller	1
NEENAH, WISCONSIN.	
Scandinavian Library Association	3
NEWARK, NEW JERSEY.	
Historical Society of New Jersey	1
NEW BEDFORD, MASSACHUSETTS.	
William Hathaway, jr	2
NEW BRUNSWICK, NEW JERSEY.	
Geological Survey of New Jersey	4
Professor George H. Cooke	1
NEW HAVEN, CONNECTICUT.	
American Journal of Science and Arts	70
American Oriental Society	21
Connecticut Academy of Arts and Sciences	28
New Haven Museum	1
Yale College	18
Professor W. P. Blake	3
Hon. C. W. Bradley	1
Professor W. H. Brewer	1
Professor G. J. Brush	6
Professor J. D. Dana	35
Professor D. C. Eaton	1
Professor E. Loomis	10
Professor C. S. Lyman	3
Professor C. O. Marsh	
Professor H. A. Newton	
Dr. Sherman	
Professor B. Silliman	
Professor A. C. Twining	
Professor A. E. Verrill	
Professor W. D. Whitney	
Professor T. D. Woolsey	

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
LEANS, LOUISIANA.	
.....	1
Academy of Natural	
.....	48
Louisiana.....	1
owler	6
es.....	2
ORK, NEW YORK.	
rean of Mines.....	1
ristian Commission ...	16
hnological Society.....	14
eographical and Sta-	
iety.....	30
urnal of Mining.....	4
urnal of Obstetrics	1
stitute.....	13
croscopical Society....	1
seum of Natural His-	
.....	2
y.....	9
Observatory.....	2
llege	2
ute	2
eopathic Sun.....	1
al Gazette	1
f Columbia College....	2
ciety.....	7
r Improved Instruction	
d Dumb.....	2
atural History.....	82
ibrary Association	2
Board of Health.....	1
sul	1
ademy of Medicine....	5
ristian Enquirer.....	3
es	2
s Sanitary Commission.	9
.....	3
Barnard.....	1
ows	1
.....	1
.....	1
. Bradford.....	1
ndler	2
g.....	1
vis	1
. Dow	3
r.....	7
Durbin	1
sk.....	1
Flügel	1
ell.....	4
.....	1
terhouse Hawkins.....	1
s.....	1
A. Joy.....	2
ball.....	1
wrence.....	4

Address.	No. of packages.
NEW YORK, N. Y.—Continued.	
James Lenox.....	1
C.Loosey, Consul General of Austria	1
Dr. B. W. McCrady.....	1
Dr. J. S. Newberry	7
Dr. J. C. Nott	3
Baron R. Osten-Sacken	1
Messrs. Parker & Douglas.....	5
Brother Paulian, Manhattan College	1
Professor Charles Rau	1
Hon. S. B. Ruggles	1
E. G. Squier.....	7
F. R. Stallknecht.....	1
Professor John Torrey.....	1
Prosper M. Wetmore.....	1
E. C. Wines.....	1
NORTHAMPTON, MASS.	
Clarke Institution for Deaf and Dumb	1
NOTRE DAME, INDIANA.	
Sister Angela Gillespie.....	1
OLATHE, KANSAS.	
Kansas Institution for Deaf and Dumb	1
OLYMPIA, WASHINGTON TERRITORY.	
State Library.....	1
OMAHA, NEBRASKA.	
Nebraska Institution for Deaf and Dumb	1
OTTAWA, CANADA.	
Legislative Library of Canada....	2
OXFORD, OHIO.	
Miami University	1
OXFORD, MISSISSIPPI.	
University of Mississippi	1
E. W. Hilgard	4
PEORIA, ILLINOIS.	
Dr. F. Brendel	3
PHILADELPHIA, PENNSYLVANIA.	
American Journal of Conchology..	3
Academy of Natural Sciences.....	177

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
PHILADELPHIA, PA.—Continued.	
American Entomological Society	9
American Journal of Medical Science	1
American Pharmaceutical Association	28
American Philosophical Society	121
Board of Controllers of Public Schools	1
Central High School	5
Franklin Institute	26
Girard College	1
Historical Society of Pennsylvania	12
House of Refuge	1
Library Company	3
Magnetic and Meteorological Observatory	2
North American Medico-Chirurgical Review	7
Numismatic and Antiquarian Society	2
Observatory of Girard College	3
Pennsylvania Institute for Blind	1
Pennsylvania Institute for Deaf and Dumb	2
Wagner Free Institute of Science	5
James Barclay	1
Rev. E. R. Beadle	1
Professor H. Bigelow	1
Lorin Blodget	3
Dr. D. D. Brinton	1
H. C. Carey	3
J. Cassin	2
G. W. Childs	2
Dr. B. H. Coates	2
T. A. Conrad	2
Professor E. D. Cope	6
Professor E. T. Cresson	1
Dr. Isaac Hays	1
Dr. G. H. Horn	1
S. P. James	1
Dr. Isaac Lea	9
Dr. J. L. Le Conte	3
Professor J. Leidy	8
Professor J. P. Lesley	2
Dr. J. A. Meigs	5
J. G. Morris	1
J. Redfield	1
Dr. J. H. M. Packard	1
W. Sharswood	1
George W. Tryon, jr	6
Professor W. Wagner	1
Dr. E. Ward	1
PHŒNIXVILLE, PENNSYLVANIA.	
Charles M. Wheatley	2
PORTLAND, MAINE.	
City Registrar	1
Portland Society of Natural History	30
POUGHKEEPSIE, NEW YORK.	
Vassar College	2
PRINCETON, NEW JERSEY.	
College of New Jersey	7
Albert D. Brown	2
Professor A. Guyot	7
PROVIDENCE, RHODE ISLAND.	
Brown University	4
Registrar General of Rhode Island	1
Rhode Island Historical Society	5
John R. Bartlett	1
John Carter Brown	1
Professor Alexis Caswell	2
Romeo Elton	1
Dr. Edwin M. Snow	4
QUEBEC, CANADA.	
Laval University	1
Literary and Historical Society	10
Observatory	1
RALEIGH, NORTH CAROLINA.	
North Carolina Institution for Deaf and Dumb	1
State Library	1
RICHMOND, VIRGINIA.	
Historical Society of Virginia	2
State Library	2
T. H. Wynne	1
ROCHESTER, NEW YORK.	
University	1
SACRAMENTO, CALIFORNIA.	
Geological Survey of California	2
State Library	2
ST. ANTHONY, MINNESOTA.	
University of Minnesota	1
ST. LOUIS, MISSOURI.	
Deutsches Institut zur Beförderung der Wissenchaften	2
Catholic Institution for Deaf and Dumb	1
City Clerk	1
Medical and Surgical Journal	5
St. Louis Academy of Sciences	84

Packages received from Europe, &c.—Continued.

Address.	No. of packages.
LOUIS, MO.—Continued.	
ɜity	5
·on Angelrodt	1
Baumgarten	1
or William Chauvenet	1
Engelmann	1
ɜauley	1
e Schuster	1
JOHN, NEW BRUNSWICK.	
ɣ of Mechanics' Institute	1
l History Society	1
ST. PAUL, MINNESOTA.	
ıota Historical Society	7
·loos	4
. THOMAS, WEST INDIES.	
ıor Krebs	1
SALEM, MASSACHUSETTS.	
Institute	62
ly Academy of Science	35
S. Packard	9
ıor F. W. Putnam	1
se	1
ɾ FRANCISCO, CALIFORNIA.	
nia Academy of Natural Sci- s	68
nia Institution for Deaf and ıb	1
Behrens	1
Bloomer	1
Bolander	3
. Stearns	7
SAVANNAH, GEORGIA.	
ical Society of Georgia	2
SHARON, CONNECTICUT.	
. Smith	1
SING SING, NEW YORK.	
J. Fisher	4
SPRINGFIELD, ILLINOIS.	
of Masonic Trowel	1
ɜor H. A. Worthen	6
STAUNTON, VIRGINIA.	
ia Institution for Deaf and ıb	1
SWANTON, CANADA.	
Dr. Perry	1
TALLADEGA, ALABAMA.	
Alabama Institution for Deaf and Dumb	1
TORONTO, CANADA.	
Canadian Institute	15
Literary and Historical Society	1
Magnetic Observatory	9
Trinity College Library	1
University of Canada	5
TUSCALOOSA, ALABAMA.	
University	1
URBANA, OHIO.	
University of Urbana	1
UTICA, NEW YORK.	
American Journal of Insanity	5
Colonel E. Jewett	2
VANDALIA, ILLINOIS.	
Illinois Historical and Archæological Society	1
WASHINGTON, D. C.	
American Annals of the Deaf and Dumb	1
American Nautical Almanac	2
Bureau of Navigation	5
Bureau of Statistics	3
Census Bureau	4
Department of Agriculture	102
Department of Education	4
Engineer Department	3
General Land Office	6
Hospital for Insane	1
Howard University	1
Hydrographic Office	11
Interior Department	1
Library of Congress	48
Light-House Board	1
Mexican minister	1
National Academy of Science	50
National Deaf-mute College	1
Navy Department	1
President of the United States	3
Quartermaster General's Office	1
Ordnance Bureau	1
Secretary of the Navy	1

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months record.
FLORIDA—Cont'd.		° ′ ″	° ′ ″	*Feet.*		
Jacksonville, Duval Co	Baldwin, A. S., M. D	30 15	82	20	B P T R	12
Ocala, Marion Co	Barker, E				T	7
Newport, Wakulla Co	Beecher, Rev. C	30 10			P T R	6
Twelve miles north of Mosquito Inlet, Volusia Co.	Chamberlain, S. N			10	T R	5
Orange Grove, Manatee Co	Clarke, W. J	27 28	82 35	10	T R	5
Manatee, Manatee Co	Coachman, B. A	27 30	82 45	6	T R	9
Port Orange, Volusia Co	Hawks, Mrs. E. H				T	7
Biscayne, Dade Co	Hunt, W. H	25 45	80 16	12	T R	1
Chattahoochee Arsenal, Gadsden Co.	Martin, M	30 48	84 48	180	T R	6
Pilatka, Putnam Co	Robinson, Gen'l G. D	29 36	81 37	152	P T R	11
GEORGIA.						
St. Mary's, Camden Co	Barker, E	30 40 23	81 26 20	15	T R	8
Near Quitman, Brooks Co	Cutter, John L	30 45	83 30 30		T R	1
Atlanta, Fulton Co	Deckner, F., and son	33 45	84	1,050	T R	8
Columbus, Muscogee Co	Fogarty, N. J				T R	1
St. Mary's, Camden Co	Hillyer, H. L	30 50	81 40	25	T R	3
Berne, Camden Co	Hillyer, H. L				T R	9
Penfield, Greene Co	Sanford, S. P				T R	12
ILLINOIS.						
Elmore, Peoria Co	Adams, W. H				R	11
Pleasant Ridge, Bureau Co	Aldrich, Verry	41 15	89 15	550	T	7
Sandwich, De Kalb Co	Ballou, N. E	41 31	88 30	665	B P T R	4
Elmira, Stark Co	Blanchard, O. A	41 12	90 15		T R	3
Andalusia, Rock Island Co	Bowman, E. H., M. D	41 25	90 46		B T	11
Peoria, Peoria Co	Brendel, F	40 43	89 30	440	B P T R	12
Springfield, Sangamon Co	Brinkerhoff, G. W	39 48	89 33		T	8
Chicago, Cook Co	Brookes, S	42	87		T	12
Alto, Lee Co	Carey, Daniel	41 45	89		T	9
Louisville, Clay Co	Chase, D. H., M. D	38 40	88 30		T R	12
Havana, Mason Co	Cochrane, J	40 20	89 50	475	T R	4
Decatur, Macon Co	Dudley, T	39 40	89 10		T R	12
Mount Sterling, Brown Co	Duncan, Rev. A	40	91 15		T R	12
Golconda, Pope Co	Eldredge, W. V	37 41	88 46		T R	9
Pana, Christian Co	Finley, T., M. D	39 24 21	89 6 5	735	T R	12
Near South Pass, Union Co	Freeman, H. C				T	2
Charleston, Coles Co	Gramesly, C	39 31	88 14		T R	9
Manchester, Scott Co	Grant, J. and C. W	39 33	90 14 36		B P T R	12
Wapella, De Witt Co	Groff, T. Louis	40 11	89 07		N	1
Quincy, Adams Co	Hearne, F. I	39 54	91 26		T R	8
Mattoon, Coles Co	Henry, W. E	39 29 10.5	45 20 38	740	T R	12
Marengo, McHenry Co	James, I. W	42 13	88 31	780	T R	12
Waterloo, Monroe Co	Jozefe, C., M. D	38 30	90 30		T	3
Chicago, Cook Co	Langguth, J. G	42	87 30	600	B P T R	12
Galesburg, Knox Co	Livingston, Prof. W	40 55	90 25		B P T R	12
Evanston, Cook Co	Marcy, Prof. Oliver	42 1	87 38	570	B T R	12
Augusta, Hancock Co	Mead, S. B	40 10	91		P T R	12
Ottawa, La Salle Co	Merwin, Mrs. E. H	41 20	88 47		T R	12
Belvidere, Boone Co	Moss, G. B	42 15	88 47	810	T R	12
Hennepin, Putnam Co	Osborn, N	41 30	89 20		T	12
Oquawka, Henderson Co	Patterson, H. N	41 8	90 30		T R	6
Near Wyanet, Bureau Co	Phelps, E. S. and Miss L. E.	41 30	89 45		T R	11
Aurora, Kane Co	Spaulding, A. and Mrs. E. D.	41 45	88 22	696	B T R	12
Dubois, Washington Co	Spencer, W. C	38 14	89 16	405	T R	12
Effingham, Effingham Co	Thompson, W., M. D	39 3	88 5	592	T R	1
Winnebago, Winnebago Co	Tolman, J. W. and Miss	42 17	89 12	900	B T R	12
Warsaw, Hancock Co	Whitaker, B	40 20	91 31		T R	11
INDIANA.						
Near Laporte, Laporte Co	Andrew, F. G			770	T R	12
Mount Carmel, Franklin Co	Applegate, J. A., and daughter.	39 22	84 51	900	T R	12
Vevay, Switzerland Co	Boerner, C. G	38 46	84 59 20.5	525	B P T R	12
New Harmony, Posey Co	Chappelsmith, J	38 08	87 50	350	B P T R	12
Laconia, Harrison Co	Crosier, A	37 47	85 50		T R	12
Spiceland, Henry Co	Dawson, W	39 48	85 18	1,025	B T R	12

of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
—Continued.		° ′ ″	° ′ ″	*Feet.*		
, Rush Co	Deem, D	39 46	85 24	800	B P T R	12
van Co	Holmes, T	39 05	87 40	.....	T R	9
ware Co	Kemper, G. W. H., M. D	40 12	85 16	.....	T R	5
asper Co	Loughridge, J. H., M. D	40 56	87 13	725	T R	9
y, Whitley Co	McCoy, Dr. F. and Miss	41 10	85 30	.....	T R	11
an Co	McHenry, B. F	39 05	87 40	.....	T R	2
Tippecanoe Co	Newton, J. W	.....	.....	.....	B T R	1
Allen Co	Robertson, R. S	41	85	800	T R	2
ewton Co	Spitler, D	40 56	87 12	725	T R	2
born Co	Sutton, G	39 5 54	84 54	569	B P T R	12
, Fountain Co	Williams, Mrs. B. C	39 55	87 40	.....	T R	9
ark Co	Williams, Mrs. B. C	.....	.....	.....	T R	2
Marion Co	Woolen, Dr. G. V., and others.	39 47	87 6	698	B P T R	11
IOWA.						
gh, Boone Co	Babcock, E	42	93 14	1,160	T R	12
ove, Adair Co	Bryant, Mrs. J. A	41 20	94 30	1,500	T R	11
n, Linn Co	Collin, Prof. A	42	91 30	.....	T	12
, Hamilton Co	Croft, Clayton I	42 30	94	.....	T	10
Clayton Co	Dickenson, J. P	43	90 50	690	T	12
Kossuth Co	Dorweiler, P	43	94 26	1,500	T	8
, Jasper Co	Failor, A	42	94	.....	T R	1
on Co	Farnsworth, P. J	41 47	90 10	630	T R	12
a Co	Hancock, E. M	.....	.....	.....	T R	9
buque Co	Horr, Asa, M. D	42 30	90 39 51	666	B P T R	11
Fayette Co	McClintock, F	42 58	91 50	1,300	B T R	12
dison, Lee Co	McCready, D	40 37	91 28	.....	T R	12
ac Co	Miller, E. and R	42 16	94 57 36	.....	T R	11
ones Co	Moulton, M. M	42 15	91 15	800	T R	12
Co	Nelson, D. B	42 20	95	900	T R	5
hnson Co	Parvin, Prof. T. S	41 36 53	91 30 10	.....	B P T R	12
ack Hawk Co	Steed, T	42 30	92 30	.....	T	8
, Harrison Co	Stern, Jacob F	41	95	928	T R	12
ocahontas Co	Strong, Oscar I	42 50	94 34	1,000	T R	2
e, Boone Co	Sullivan, Z. T	42 6	93 40	1,200	T R	3
, Hardin Co	Townsend, N	42 32	93 20	.....	T R	9
da, Floyd Co	Wadey, H	43	93	.....	T	12
uscatine Co	Walton, J. P	41 25	91 02	582	B T R	3
, Buchanan Co	Warne, G., M. D	42 25	92 06	940	B T R	12
ndence, Buchanan	Wheaton, Mrs. D. B	42 29 25	91 50 08	.....	T R	12
Harrison Co	Witter, D. K. and M. E	41 38	95 40	.....	T R	12
uth Co	Warren, J. H	43 05	94 15	.....	T	11
rie, Jones Co	Woodworth, S	42 15	.....	800	B T R	12
KANSAS.						
on Co	Beckwith, W	38 50	94 30	.....	T R	12
tory Co	Cotton, J. M	42	93 30	790	T R	1
n, Jefferson Co	Cotton, J. M., and E. Adams.	39	95 30	.....	T R	5
offey Co	Crocker, A	38 08	95 27	825	R	5
le, Crawford Co	Daniels, P	37 53	94 85	.....	T R	5
, Woodson Co	Groesbeck, Mrs. E. W	37	.....	.....	T R	4
chison Co	Horn, Dr. H. B. and Miss C.	39 42	95	1,000	T R	12
gs, Cherokee Co	Ingraham and Hyland	37 03	94 37	.....	T R	12
tler Co	Lamb, Dr. W. M	37 33	97 03	.....	T R	6
tley Co	Mudge, Prof. B. F	39 12	96 40	1,300	B T R	12
offey Co	Shoemaker, J. G	38 06 28	95 27 39	.....	B T R	4
ouglass Co	Snow, Prof. F. H	38 55	95 15	850	B P T R	12
, Leavenworth Co	Stayman, Dr. J	39 20	94 33	787	T R	12
Co	Walrad, L. D	38 30	95 30	.....	T R	12
on Co	Walters, Dr. J	39 27	95 10	1,172	T	12
e, Morris Co	Woodworth, A	38 40	96 30	.....	T R	12
KENTUCKY.						
le Co	Beatty, O	37 40	84 30	900	B T R	9
efferson Co	Blackburn, Dr. C. B	.....	.....	.....	B P T R	1
Clark Co	Martin, Dr. S. D	38 04	.....	978	B P T R	12
oln Co	Shriver, H	37 34	84 30	900	B P T R	11
efferson Co	Young, Mrs. L	38 06 55	85 24 13	570	B P T R	12

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months reported.
LOUISIANA.		° ′ ″	° ′ ″	*Feet.*		
Anchorage Plantat'n, Bossier Par	Carter, J. H	32 30	93 45	.....	T	11
Ponchatoula, Tangipahoa Par	Collins, H. C	30 30	90 20	.....	BTR	4
New Orleans, Orleans Par	Foster, Captain R. W	.....	.....	.....	BTR	12
Cheneyville, Rapides Par	Jackson, R. S	31	92 20	.....	T	9
MAINE.						
Houlton, Aroostook Co	Fernald, C. H	46 07	67 49 24	470	TR	12
Orono, Penobscot Co	Fernald, M. C	44 53 10	68 38 57	134	BPTR	12
Gardiner, Kennebec Co	Gardiner, R. H	44 0 55	69 45 50	.....	BPTR	12
Cornish, York Co	Guptill, G. W	43 40	70 44	800	TR	12
Lisbon, Androscoggin Co	Moore, Asa P	44	70 4	130	TR	12
Standish, Cumberland Co	Moulton, J. P	43 45	70 30	280	TR	1
Steuben, Washington Co	Parker, J. D	44 31 21	67 37 34	50	TR	4
Mount Desert, Hancock Co	Parker, J. D	.....	.....	.....	TR	7
Williamsburg, Piscataquis Co	Pitman, Edwin	45 21	69 71	.....	TR	11
Oxford, Oxford Co	Smith, H. D	44 08	70 33	.....	TR	12
Surry, Hancock Co	Tripp, Oscar H	44 30	68 30	50	TR	6
Cornish, York Co	West, Silas	43 33	70 50	784	BTR	12
West Waterville, Kennebec Co	Wilbur, Benjamin F	44 30	69 46	.....	TR	12
MARYLAND.						
Fallston, Harford Co	Curtis, G. G	39 30	.....	300	TR	3
Annapolis, Anne Arundel Co	Goodman, W. R	38 58	76 29	20	BPTR	12
Frederick, Frederick Co	Hanshew, H. K	39 24	77 26 30	.....	BTR	6
Emmittsburg, Frederick Co	Jourdan, Prof. C. H	39 40	77 20	.....	BPTR	12
Woodlawn, Cecil Co	McCormick, J. O	39 38	76 04	.....	BTR	12
St. Mary's City, St. Mary's Co	Stephenson, Rev. J	38 10	76 30	45	TR	2
Woodstock College, Baltimore Co	Valentine, A. X	39 55	76 52	400	TR	1
MASSACHUSETTS.						
Boston, Suffolk Co	Appleton, F. H	42 20	71	.....	T	1
Richmond, Berkshire Co	Bacon, W	42 23	73 20	1,000	TR	10
West Newton, Middlesex Co	Bixby, J. H	42 21	71 17	554	TR	10
Newbury, Essex Co	Caldwell, J. H	42 45	70 55	25	T	7
Lunenburg, Worcester Co	Cunningham, Geo. A	42 35	71 43	450	BTR	12
Hinsdale, Berkshire Co	Dewhurst, Rev. E	43 27	73 7	.....	BTR	10
Worcester, Worcester Co	Draper, J., M. D	42 16 17	71 48 13	528	BPTR	12
Lawrence, Essex Co	Fallon, J	42 42 13	71 10 13	143	BPTR	11
Williamstown, Berkshire Co	Hopkins, Prof. A	42 42 37	70 12 42	686	BTR	12
Topsfield, Essex Co	Merriam, S. A	42 38	70 57	.....	BPTR	10
Mendon, Worcester Co	Metcalf, J. G., M. D	42 6 23	71 33 35	.....	BTR	12
N. Billerica, Middlesex Co	Nason, Rev. E	42 35 9	70 16 30	.....	BT	12
Georgetown, Essex Co	Nelson, S. Aug	42 42	71	.....	TR	5
Cambridge, Middlesex Co	Perry, Rev. Jno. B	42 20	71 11	40	T	12
Kingstown, Plymouth Co	Newcomb, G. S	42	70 45	60	TR	11
New Bedford, Bristol Co	Rodman, S	41 39	70 56	90	BPTR	11
Amherst, Hampshire Co	Snell, Prof. E. S	42 22 17	72 34 30	267	BPTR	12
Milton, Norfolk Co	Teele, Rev. A. K	42 14 37	71 6 1	115	TR	12
MICHIGAN.						
Litchfield, Litchfield Co	Bullard, R	42	84 46	1,040	BTR	12
Otsego, Allegan Co	Chase, M., M. D	.....	.....	.....	T	12
Ontonagon, Ontonagon Co	Ellis, Edwin, M. D	46 52	89 30	620	T	12
Adrian, Lenawee Co	Helme, Miss L. May	41 57	83 57	1,240	TR	6
Detroit, Wayne Co	Higgins, F. W	42 20	82 03	.....	TR	11
Grand Rapids, Kent Co	Holmes, Dr. E. S	43	85 40	780	T	12
Macon, Lenawee Co	Howell, D	.....	.....	.....	TR	1
Lansing, Ingham Co	Kedzie, Prof. R. C	.....	.....	.....	BPTR	10
Olivet, Eaton Co	Kemp, Prof. A. F	46 26	84 94	968	BTR	1
Kalamazoo, Kalamazoo Co	Mapes, H. H	.....	.....	.....	N	12
Pleasanton, Manistee Co	Millard, Jos. D	44 25	86 10	750	TR	8
Muskegon, Muskegon Co	Pattison, H. A	.....	.....	.....	BTR	8
Alpena, Alpena Co	Paxton, J. M	45 02	83 05	574	BTR	12
Northport, Leelenaw Co	Smith, Rev. G. N	45 08	85 41	592	TR	12
Coldwater, Branch Co	Southworth, N. L	.....	.....	.....	TR	12
Homestead, Benzie Co	Steele, Rev. G. N	44 35	86 30	.....	T	2
Grand Rapids, Kent Co	Streng, L. H	.....	.....	.....	TR	9
Monroe, Monroe Co	Whelpley, Miss F. E	41 58	83 23	590	TR	11
Central Mine, Keweenaw Co	Whittlesey, S. H	47	87 54	1,177	TR	12
Benzonia, Benzie Co	Wilson, W	44 31	86	620	T	7
Ann Arbor, Washtenaw Co	Winchell, Mrs. N. H	42 16	83 44	840	TR	9

of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
MINNESOTA.		° ′ ″	° ′ ″	*Feet.*		
hington Co	Babcock, Dr. & Mrs. B. F.	44 50	93	950	T R	7
, Hennepin Co	Cheney, Wm	44 48	93 10	856	B P T R	12
atonwan Co	Murphy, W. W	44	94 30	.....	T R	12
nsey Co	Paterson, Rev. A. B	44 54 46	94 4 54	800	T R	12
h Reservation, Beck-	Pyle, Dr. D	47 50	95	.....	T	3
Brown Co	Roos, Chas	44 46	94 26	821	T R	12
Meeker Co	Wadsworth, H. L	45 12	94 45	.....	T R	6
, Lake Co	Wieland, C	47 12	96 19	657	T R	12
y Co	Woodbury, C. W. & C. E.	44 31	94 25	.....	T R	12
cLeod Co	Young, T. M	45 10	94 20	.....	T R	11
MISSISSIPPI.						
e, Marshall Co	Abernethy, W. M	35	90	434	T R	1
a, Neshoba Co	Bowden, L. A	32 45	89 15	550	T R	11
Springs, Marshall Co	Coleman, T. B	34 40	.....	.....	T R	7
nderdale Co	Florer, T. W., M. D	32 25	88 05	83	T R	[redacted]
nds Co	Jackson, R. S	.....	.....	.....	B T R	
haven, Lawrence Co	Keenan, Miss W. E. A	31 34	90 40	.....	T R	
Lowndes Co	Lull, Jas. S	35 30	88 29	227	B T R	12
lams Co	McCary, W	31 34	91 24 42	.....	B T R	5
, Lawrence Co	Moore, T. B	31 37	90 15	430	T R	7
alabusha Co	Payne, John S	33 45	90	.....	T R	6
alabusha Co	Ringgold, R. S., M. D	33 45	90	.....	T R	1
Jasper Co	Robinson, Rev. E. S	32	85	285	B P T R	11
MISSOURI.						
Buchanan Co	Bullard, Rev. H	39 45	94 53	.....	T R	6
le, Cass Co	Christian, John	.....	.....	.....	T R	9
ty, Cole Co	De Wyl, N	38 20	92	650	B T	12
St. Louis Co	Fendler, Aug	38 29	90 45	482	B P T R	12
g, Johnson Co	Hall, S. K	38 45	93 40	600	B	1
t Co	Kaucher, Wm	39 58 40	95 10	1,100	B P T R	12
Academy, Greene Co	McCord, R. H	37 30	93 30	.....	T R	1
lt Co	Martin, Horace	40 20	95 30	.....	T R	6
k Co	Race, Jas. A	37 30	93 20	1,000	T R	1
s Co	Ruggles, H	37 38	91 33	.....	T R	12
, Jackson Co	Salisbury, S. W	39 5	94 40	710	B T	11
efferson Co	Smith, John M	38 11	90 37	475	T R	12
. Louis Co	Stuntebeck, Rev. F. H	38 37 28	90 15	470	B P T R	12
MONTANA.						
issoula Co	Reinhard, J. P., and J. M. Menesinger.	46 45	113 45	3,900	T	3
City, Deer Lodge Co	Stuart, Granville	46 40	112 40	4,240	T R	12
NEBRASKA.						
Washington Co	Bowen, John S	41 22	96 12	1,350	T	3
ue, Sarpy Co	Caldwell, Mrs. E. E	41 08	95 46	.....	T R	12
caster Co	Goodrich, G. A	40 55	96 52	1,647	T R	2
Hills, Burt Co	Hamilton, Rev. W	42 10	96	.....	T R	12
ity, Otoe Co	Pettenger, J. M., and P. Zahner.	40 42	95 45	1,225	T	12
shington Co	Seltz, Chas	41 50	96	975	T R	11
Dixon Co	Smith, L. H	43	97 20	.....	T R	8
NEW HAMPSHIRE.						
Carroll Co	Brewster, Alfred	48 48	71 18	.....	T R	12
oos Co	Brown, Branch	44 40	71 07	1,000	T R	12
Merrimack Co	Colby, Alfred	43 06	71 35	730	T R	12
Merrimack Co	Couch, E. D	43 23	71 20	500	T	4
m, Hillsboro Co	Hurlin, Rev. W	.....	.....	.....	N	12
Coos Co	Kidder, L. D	44 20	71 15	.....	T R	12
Coos Co	Odell, F	44 23	71 6	700	B T	2
rrimack Co	Wheeler, John T	43 12	71 29	550	T	4
NEW JERSEY.						
nship, Burlington Co	Beans, Thomas J	39 59	74 54	.....	T R	12
, Camden Co	Boadle, J., and J. L. Lippincott.	.....	.....	.....	P T R	12

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months observed.
NEW JERSEY—Cont'd.		° ′ ″	° ′ ″	*Feet.*		
Paterson, Passaic Co	Brooks, William	40 55	74 10	60	T R	12
South Orange, Essex Co	Chandler, W. J., M. D	40 44 25			P T R	4
Trenton, Mercer Co	Cook, E. R	40 14	74 46 30	60	B T R	11
Newfield, Gloucester Co	Couch, E. D	39 30	74 50	180	T	7
Lesser Cross Roads, Somerset Co	Fleming, J				T	8
New Brunswick, Middlesex Co	Hasbrouck, I. E				B P T R	5
Vineland, Cumberland Co	Ingram, J., M. D				B P T R	12
Camden, Camden Co	Martindale, I. C				N	2
New Germantown, Hunterdon Co	Noll, A. B	42 40	74 45		B T R	12
Rio Grande, Cape May Co	Palmer, Mrs. J. R	39 16	74 42		T R	12
Greenwich, Cumberland Co	Sheppard, Miss R. C	39 20	75 25	30	B P T R	12
Newark, Essex Co	Whitehead, W. A	40 45	74 10	35	B T R	12
NEW YORK.						
Ardenia, Philipstown, Putnam Co	Arden, T. B	40 20 22	73 53 22	180	T R	12
Milo, Yates Co	Baker, G. D	42 30		868	T R	12
South Trenton, Oneida Co	Barrows, Captain S	43 10	74 56	835	T R	12
Palermo, Oswego Co	Bartlett, E. B	43 26	77 26	327	T R	11
Minaville, Montgomery Co	Bussing, J. W	42 54	74 15		T R	12
Lockport, Niagara Co	Clark, B. W	43 9	79		T R	7
Fort Edward, Washington Co	Cooley, Prof. J. S	43 13	73 42		B T	5
Little Genesee, Allegany Co	Edwards, D	42 0 15	78 20	1,500	B T R	12
Rochester, Monroe Co	Fiske, W. M. L., M. D	43 8	77 51	525	B T R	2
Bannerville, Schoharie Co	France, G. S	42 38		1,200	T R	4
Newburgh, Orange Co	Gardiner, J. H	41 30 53	74 1	96	B T R	11
Depauville, Jefferson Co	Haas, H	44 10	76 3	350	T R	12
Hudson, Columbia Co	Hachenberg, G. P., M. D	42 14	73 46		P T R	1
Near Kingston, on the Hudson, Ulster Co.	Hendricks, D. B	41 50	74 2	150	T R	12
Nichols, Tioga Co	Howell, R	42	76 32		T	12
North Argyle, Washington Co	Hunt, G. W	43 18	72 29	290	B T R	1
South Hartford, Washington Co	Ingalsbe, G. M	43 18	73 21 3	400	T R	12
Buffalo, Erie Co	Ives, W	42 50	78 56	600	B T R	12
Newark Valley, Tioga Co	Johnson, Rev. S. W				T R	12
New York, New York Co	Joy, Prof. C. A	40 43	74 5	100	B P T R	3
Cooperstown, Otsego Co	Keese, G. Pomeroy	42 50	74 54	1,200	T R	12
Flatbush, Kings Co	Mack, E. T	40 37 17	74 1 33	54	B T R	12
Brooklyn, Kings Co	Maillo, I. P	40 40	73 56	125	B P T R	7
Oswego, Oswego Co	Malcolm, W. S	43 28	76 30	250	B T R	12
New York, New York Co	Marsh, Mrs. M. M	40 42	74 1 8	25	B P T R	6
Rochester, Monroe Co	Mathews, H. W	43 8	77 51	525	B P T R	8
Brooklyn, Kings Co	Meeker, J. S				R	1
Leyden, Lewis Co	Merriam, C. C	43 32 30	75 24		B T R	6
Farmingdale, Queens Co	Merritt, John C	40 40 40	73 30	102	N	11
Throg's Neck, Westchester Co	Morris, Miss E	40 49 15	73 48 45	43	T	12
New York, New York Co	Morris, Prof. O. W	40 50 25	73 56 30	165	B P T R	12
New York, New York Co	Naval Hospital	40 41 30	74 1	56	B T R	12
Central Park, New York Co	Observatory	40 45 58	73 57 58	97	B P T R	12
North Volney, Oswego Co	Partrick, J. M				T	12
Sloansville, Schoharie Co	Potter, G. W	42 41	74 31		T R	1
Gouverneur, St. Lawrence Co	Russell, C. H	44 19	75 29		B T R	11
Brookhaven, Suffolk Co	Smith, E. A., and daughters.	40 49	72 36	13	T R	12
Cazenovia, Madison Co	Soule, Prof. W	42 55	75 46	1,260	B T	12
Oneida, Madison Co	Spooner, Dr. S	43 4	75 50	500	T R	12
Caldwell, Warren Co	Strong, A. M	43 24	72 46	300	B P T R	2
Luzerne, Warren Co	Strong, A. M				B P T R	4
Vassar College, Poughkeepsie, Dutchess Co.	Swallow, Miss	41 40 50	42 55 33		B T R	9
Waterburgh, Tompkins Co	Trowbridge, D	42 30	77 15	800	T R	11
Utica, Oneida Co	Williams, J. Gilbert	43 10	74 57	518	T R	12
White Plains, Westchester Co	Willis, O. R., and daughters.	41 5	73 40	273	T	12
North Hammond, St. Lawrence Co	Wooster, C. A	44 30	75 41		B T R	12
Houseville, Lewis Co	Yale, Walter D	43 40	75 32		T R	10
NORTH CAROLINA.						
Statesville, Iredell Co	Allison, T. P	35 30	80 30		T R	12
Asheville, Buncombe Co	Aston, Edw. J				T R	12
Goldsboro, Wayne Co	Adams, Prof. E. W	35 20	77 51	102	T R	12
Warrenton, Warren Co	Foote, H. A	36 15	78 15		T R	12
Asheville, Buncombe Co	Hardy, J. F. E., M. D	35 30	82 31	2,250	B T	12
Oxford, Granville Co	Hicks, W. R., M. D	36 23	78 14		T R	11

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
NORTH CAROLINA—Cont'd.		° ′ ″	° ′ ″	*Feet.*		
Attaway Hill, Stanly Co	Kron, F. J.	35 25	80	850	T R	12
Near Raleigh, Wake Co	Murdock, W. H.	36 37	78 45	385	R	1
Chapel Hill, Orange Co	Patrick, Prof. D. S.				T	5
Kenansville, Duplin Co	Sprunt, Rev. J. M.	34 53	75 3	40	B T	5
OHIO.						
Bellefontaine, Logan Co	Barringer, W.	40 23	83 45	1,169	T R	6
New Lisbon, Columbiana Co	Benner, J. F., and W. R. Smiley.	40 45	80 45	961	B P T R	3
Quaker Ridge, Morgan Co	Bingman, T. J.	40 30	82	555	T R	8
North Fairfield, Huron Co	Burras, O.	41 8	82 40	660	T R	12
Bowling Green, Wood Co	Clarke, J.	41 22	83 40	700	T R	10
Gambier, Knox Co	Compton, F., and others	40 20 30		1,000	B P T R	11
Bethel, Clermont Co	Crane, G. W.	39	84	555	T R	12
Steubenville, Jefferson Co	Doyle, Joseph B.	40 45	80 47		B T R	12
Little Mountain, Geauga Co	Ferriss, E. J.	41 38	81 16	600	B P T R	12
College Hill, Hamilton Co	Hammitt, John W.	39 19	70 14 45	800	T R	12
Cincinnati, Hamilton Co	Harper, G. W.	39 6	84 29		B T R	10
Westerville, Franklin Co	Haywood, Prof. J.	40 4	83		B P T R	12
Springfield, Clark Co	Hachenberg, G. P., M. D.				B P T R	5
Oberlin, Loraine Co	Herrick, L.	41 20	81 15	800	T R	11
Wooster, Wayne Co	Hoover, W.	40 49	81 55	872	T R	2
Kelley's Island, Erie Co	Huntingdon, G. C.	41 35 44	82 42 32	587	B T R	12
Cleveland, Cuyahoga Co	Hyde, G. A.	41 30	80 40		B T R	12
Edgerton, Williams Co	Knight, A. B.	41 32	83 45	831	T R	2
Oxford, Butler Co	McFarland, Prof. R. W.	39 30	84 46	950	B P T R	12
Ripley, Huron Co	Marsh, Mrs. M. M.	41	82 30	965	B P T R	5
Hillsboro, Highland Co	Mathews, J. McD.	39 13			B P T R	12
Carthagena, Mercer Co	Muller, Dr. R.	40 28	84 33		B P T R	4
North Bass Island, Ottawa Co	Morton, George R., M. D.	41 36	82 41 53			12
Gilmore, Tuscarawas Co	Moore, S. M.	40 18	81 18	1,180	T	5
Margaretta Township, Erie Co	Neill, Thomas	41 27.	82 46		B P T R	12
Jacksonburg, Butler Co	Owsley, J. B., M. D.	39 30	84 17	1,152	T R	12
Cincinnati, Hamilton Co	Phillips, R. C.				B T R	12
Salem, Columbiana Co	Pollock, Rev. J. E.	40 54	81	950	T R	12
Gallipolis, Gallia Co	Rodgers, Alexander P.	39	82	600	T R	8
Kenton, Hardin Co	Smith, C. H., M. D.			543	T R	12
Adams Mills, Muskingum Co	Stillwell, C. A.	40 5	82	900	P T R	7
Milnersville, Guernsey Co	Thompson, Rev. D.	40 10	81 45		T R	4
New Birmingham, Guernsey Co	Thompson, Rev. D.				T R	8
Toledo, Lucas Co	Trembley, J. D., M. D.	41 38	83 30		B T R	6
Mount Auburn, Hamilton Co	White, J. H.			1,000	B P T R	12
Williamsport, Pickaway Co	Wilkinson, J. R.	39 37 4	83 7 30		T R	6
Urbana, Champaign Co	Williams, Prof. M. G.	40 6	83 43	1,015	B T R	12
Wooster, Wayne Co	Winger, M.	40 48 47	81 55 37	872	T R	6
OREGON.						
Portland, Multnomah Co	Gilliland, S. W., & J. S. Ried.	45 31 15	122 26 6	45	B P T R	11
Eola, Polk Co	Pierce, Thomas	44 57	123 05	500	T R	12
Astoria, Clatsop Co	Wilson, Louis	46 11 28	123 49 32	52	B P T R	6
PENNSYLVANIA.						
Pittsburg, Alleghany Co	Albree, C.				T R	10
Tioga, Tioga Co	Bentley, E. T.	42	77	1,000	T R	12
Carlisle, Cumberland Co	Cook, Dr. W. H.				B T R	12
Plymouth Meeting, Montgomery Co.	Corson, M. H.	40 6			B P T R	12
Ashland, Schuylkill Co	Curtis, A.				T	8
Pocopson, Chester Co	Darlington, F.	39 54	75 37	218	T R	12
Dyberry, Wayne Co	Day, Theodore	41 36	75 19		T R	8
Harrisburg, Dauphin Co	Egle, Dr. W. H.	40 16	76 15		B T R	7
Near Pennsville, Clearfield Co	Fenton, E.	41	78 40	1,400	B T R	12
Blooming Grove, Pike Co	Grathwohl, John	41 30	75		T R	11
Fallsington, Bucks Co	Hance, E.	40 12	74 48	30	B T R	12
Tamaqua, Schuylkill Co	Haworth, J.	40 45	76	700	T	10
Hazleton, Luzerne Co	Haworth, J.			1,800	T	1
Mount Joy, Lancaster Co	Hoffer, J. R., M. D.	40 8	76 32		B T	8
Ashland, Schuylkill Co	Honeyman, Rev. W. E.	40 51	76 20	1,005	T R	5
Brownsville, Fayette Co	Hubbs, J. Allen	40	80		T R	12
Lewisburg, Union Co	James, Prof. C. S.	40 58	76 58		B P T R	12

List of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	Nos. months received.
PENNSYLVANIA—Cont'd.		° ′ ″	° ′ ″	*Feet.*		
Whitehall, Lehigh Co	Kohler, E	40 44	75 28	450	T R	11
Philadelphia, Philadelphia Co	Kirkpatrick, J. A	39 57	75 11	60	B P T R	12
Newcastle, Lawrence Co	McConnell, E. M	40	80 12	.....	T R	12
Westchester, Chester Co	Martin, Dr. George	39 57 31	75 36 3	460	B P T R	11
Germantown, Philadelphia Co	Meehan, T	.....	.....	.....	T	12
Williamsport, Lycoming Co	Moyer, H. C	41 19	81 30	533	T	2
Philadelphia, Philadelphia Co	Naval Hospital	39 56	75 10	36	B T R	12
Johnstown, Cambria Co	Peelor, D	.....	.....	1,200	B P T R	12
Reading, Berks Co	Raser, J. Heyl	40 20	75 57	.....	T R	12
Greencastle, Franklin Co	Rhode, S. W	39 45	77 30	650	T R	3
Abington, Luzerne Co	Sisson, R	41 30	75 45	.....	T R	12
Cannonsburg, Washington Co	Smith, Dr. Wm	40 16 41	80 10	850	B T R	12
Mooreland, Montgomery Co	Spencer, Miss Anna	40	75 11	250	B P T R	12
Ephrata, Lancaster Co	Spera, W. H	40 12	76 15	.....	P T R	12
Salem, Wayne Co	Stocker, J. D	41 30	75 30	.....	T R	12
Connellsville, Fayette Co	Taylor, John	40	79 36	.....	T R	12
Beaver, Beaver Co	Taylor, Rev. R. T	40 43	80 23	.....	T R	12
Franklin, Venango Co	Tolman, Rev. M. A	41 24	79 51	980	T R	12
Germantown, Philadelphia Co	Turner E., C. E	.....	.....	.....	B T R	12
Fountain Dale, Adams Co	Walker, S. C	39 44	77 18	.....	P T R	12
RHODE ISLAND.						
Newport, Newport Co	Barber, W. A	41 28 22	71 21 14	25	T R	7
Newport, Newport Co	Crandell, Wm. H	41 28 22	71 21 14	25	T R	5
SOUTH CAROLINA.						
Aiken, Barnwell Co	Cornish, Rev. J. H	33 32	81 34	565	B T R	12
Evergreen, Anderson Co	Earle, E. S	34 30	82 50	.....	T R	4
Bluffton, Beaufort Co	Guerard, S. St. J., M. D	32 10	81	.....	T R	12
Gowdeysville, Union Co	Petty, Chas	34 50	81 36	600	T R	12
Fort Hill, York Co	Springs, R. A., jr	35	81	.....	T	4
TENNESSEE.						
Lookout Mountain Educational Institute, Hamilton Co.	Bancroft, Rev. C. F. P	35	81 5	2,200	B T	12
Austin, Wilson Co	Calhoun, P. B	.....	.....	.....	T R	10
Greeneville, Greene Co	Doak, S. S. & W. S	36 5	82 51	.....	T R	6
Lagrange, Fayette Co	Franklin, W. E	35 7 30	89 15 25	462	T R	6
Memphis, Shelby Co	Goldsmith, E	35 8	90	262	B P T R	3
Trenton, Gibson Co	Grigsby, Wm. T	36	89	.....	T R	10
Elizabethtown, Carter Co	Lewis, C. H	36 25	82 15	1,500	T R	12
Knoxville, Knox Co	Payne, Prof. J. K	36	84	990	B P T R	9
Clarksville, Montgomery Co	Stewart, Prof. W	36 29	87 13	481	B P T R	12
McMinnville, Warren Co	Wright, T. P	35 42	85 57	1,000	T	8
TEXAS.						
Clarksville, Red River Co	Anderson, Rev. J	33 40	.....	.....	T	7
Houston, Harris Co	Baxter, Miss E	29 50	95 30	50	T	6
Palestine, Anderson Co	Brooks, N. S	31 40	95 35	480	T R	8
Bremond, Robertson Co	Combs, B	.....	.....	.....	R	5
Bluff P. O., Fayette Co	Fietsam, J	30	97	180	T R	7
Near Gilmer, Upshur Co	Glasco, J. M	32 46	94 51	950	T R	12
Blue Branch, Burleson Co	Goode, W. H	30 27	97 26	600	T R	6
Lavaca, Calhoun Co	Heaton, L. D	28 30	96 40	17	T R	8
San Antonio, Bexar Co	Pettersen, F	29 28	98 24	564	P T R	5
Oakland, Texas Co	Simpson, F	29 65	96	.....	T R	11
Austin, Travis Co	Van Nostrand, J	30 29	97 46	650	T R	12
Blue Branch, Burleson Co	Wade, F. S	30 25	97 26	600	T R	9
Sand Fly, Burleson Co	Wade, F. S	.....	.....	.....	T R	1
Clinton, De Witt Co	White, Dr. A. C	29	97 37	.....	T R	12
Lockhart, Caldwell Co	Woodruff, L	.....	.....	.....	T R	7
UTAH.						
Coalville, Summit Co	Bullock, T	40	111	5,600	T	9
St. George, Washington Co	Johnson, C	37 11	114	.....	T	3
Harrisburg, Washington Co	Lewis, James	.....	.....	.....	R	7
Salt Lake City, Salt Lake Co	Phelps, W. W	40 45	111 26	.....	T	10

st of meteorological stations and observers, &c., for the year 1870—Continued.

Station.	Name of observer.	North latitude.	West longitude.	Height.	Instruments.	No. months received.
VERMONT.		° ′ ″	° ′ ″	*Feet.*		
ddison Co	Barto, D. C. and M. E	44	74	.....	T R	12
Orleans Co	Currier, J. M	44 55	72 20	750	T R	11
g, Essex Co	Cutting, H. A	44 28	71 41	1,124	B P T R	12
k, Windsor Co	Doten, H., & L. A. Miller	43 36	72 35	698	T R	12
y, Orleans Co	Kennedy, J. C	.....	.....	.....	T R	1
, Orange Co	Paine, C. S	43 55	73 36	650	T R	12
ry, Addison Co	Sheldon, H. A	43 59	73 10	398	B P T R	6
y, Orleans Co	Wild, Rev. E. P	44 40	72 30	1,100	T R	12
, Rutland Co	Williams, Rev. R. G	.....	.....	.....	B P T R	12
, Chittenden Co	Wing, Minerva E	.....	.....	.....	T R	12
VIRGINIA.						
Hill, Isle of Wight Co	Binford, R	36 50	76 50	100	T R	7
Fairfax Co	Bowman, J. B. and G. A	38 53 39	77 11	400	T R	5
le, Wythe Co	Brown, Rev. James A	36 55	81 4	2,400	B T R	12
n, Rockbridge Co	Campbell, Prof. J. L	.....	.....	.....	B T R	3
, Augusta Co	Covell, J. C	38 8	78 46	1,261	B P T R	12
n Township, Fairfax Co	Gillingham, C	38 40	77 15	150	B T R	2
Iome, Surry Co	Jones, B. W	37 10	76 46	.....	T R	11
sville, Fauquier Co	Martin, W. A	38 50	78	.....	T R	12
chburg, Bedford Co	Meriwether, C. I	37 18	79 19	800	T	12
nsontown, Northamp-	Moore, C. R	37 22	75 46	40	B T R	12
Norfolk Co	Naval Hospital	36 25	76 25	25	B T R	12
rkham Station, Fau- o.	Payne, L. E	39	78	.....	T R	2
ington, Rockbridge Co	Ruffner, W. H	37 4	79 22	1,000	T R	8
, Elizabeth City Co	Sherman, J. M	37 5	76 20	5	T R	12
, Pulaski Co	Stalnaker, J. W., M. D	37	80	1,800	T R	6
Hill, King George Co	Tayloe, E. T	.....	.....	60	T R	12
rfax C. H., Fairfax Co	Thrift, Miss L. R	38 53 39	77 21	500	T R	7
lmont, Fauquier Co	Williams, F	38 50	78	900	T R	12
Fairfax Co	Williams, H. C	38 53	77 12	400	B P T R	12
INGTON TERRITORY.						
t, Waukiakum Co	McCall, C	46 15	123 30	45	T	7
Island Light-House, Co.	Sampson, Alex. M	.....	.....	.....	T R	11
lla, Walla-Walla Co	Simmons, A. H	46 5	118 52	930	T R	1
shington, King Co	Whitworth, Mr. and Mrs. J. E.	47	.....	.....	T	7
WEST VIRGINIA.						
Hampshire Co	McDowell, W. H	.....	.....	.....	T	3
Lewis Co	Owen, Benjamin	39	.....	.....	T	6
Cabell Co	Roffe, C. L	38 30	82 16	600	T R	7
WISCONSIN.						
s, Waupaca Co	Breed, E. E	44 51	88 37 30	.....	T R	11
n, Columbia Co	Curtis, W. W	43 26	89 19	.....	T R	12
Dane Co	Daniells, Prof. W. W	43 5	89 24	1,068	B P T R	12
Sheboygan Co	De Lyser, John	43 36	87 54	670	T	11
on, Juneau Co	Dungan, J. L	43 45	90	.....	T	6
, Outagamie Co	Foye, Prof. J. C	44 10	88 35	800	B T	5
e, Milwaukee Co	Lapham, I. A., LL. D	43 3	87 56 10	604	B P T R	12
c, Manitowoc Co	Lüps, Jacob	44 7	87 45	658	B T R	12
, Waupaca Co	Mead, H. C	44 20	89 11	900	T	1
, Sheboygan Co	Moeller, G	43 44	88 7	.....	B T R	3
Marathon Co	O'Donoghoe, J	45	89 30	750	T R	12
ity, Monroe Co	Pegler, Rev. G	43 45	91 40	700	T R	8
, Rock Co	Shintz, H. J	42 30	89	1,700	T R	12
, Waushara Co	Spaulding, J	44	89 20	1,200	R	7
Bayfield Co	Tate, Andrew	.....	.....	.....	T	12
Sauk Co	Waite, M. C	43 27 1	89 45 1	920	T R	12
l, Wabash Co	Whiting, W. H	.....	.....	600	T R	12
Bay, Door Co	Wright, R. M	45	87 30	647	T R	11

DEATHS OF OBSERVERS.

H. A. Sheldon, Middlebury, Vermont.
G. Moeller, Plymouth, Wisconsin, March 14, 1870.

COLLEGES AND OTHER INSTITUTIONS FROM WHICH METEOROLOGICAL REGISTERS WERE RECEIVED DURING THE YEAR 1870, INCLUDED IN THE PRECEDING LIST.

State.	Institution.	Location.
Nova Scotia	Acadia College	Wolfville.
Alabama	Greene Springs School	Havana.
California	Pacific Methodist College	Vacaville.
Connecticut	Wesleyan University	Middletown.
Georgia	Mercer University	Penfield.
Illinois	Lombard University	Galesburg.
	Northwestern University	Evanston.
Indiana	City Hospital	Indianapolis.
Iowa	Cornell College	Mount Vernon.
	Iowa State University	Iowa City.
Kansas	Agricultural College	Manhattan.
	State University	Lawrence.
Maryland	Mount St. Mary's College	Emmittsburg.
	Woodstock College	Baltimore County.
Massachusetts	Amherst College	Amherst.
	State Lunatic Hospital	Worcester.
	Williams College	Williamstown.
Michigan	Agricultural College	Lansing.
	Olivet College	Olivet.
Mississippi	Mississippi College	Clinton.
Missouri	St. Louis University	St. Louis.
New Hampshire	St. Paul's School	Concord.
New York	Columbia College	New York.
	Erasmus Hall Academy	Flatbush.
	Oneida Conference Seminary	Cazenovia.
	Rutgers Female College	New York.
	Vassar College	Poughkeepsie.
North Carolina	Webster Institute	Kenansville.
	State University	Chapel Hill.
Ohio	Kenyon College	Gambier.
	Miami University	Oxford.
	Mount Auburn Young Ladies' Institute	Mount Auburn.
	Otterbein University	Westerville.
	Theological Seminary	Carthagena.
	Urbana University	Urbana.
	Woodward High School	Cincinnati.
Pennsylvania	Beaver Seminary	Beaver.
	Jefferson College	Canonsburg.
	Lewisburg University	Lewisburg.
Tennessee	East Tennessee University	Knoxville.
	Lookout Mountain Educational Institute	Hamilton County.
	Stewart College	Clarksville.
	Tusculum College	Greeneville.
Texas	Institution for Deaf and Dumb	Austin.
Vermont	Normal School	Castleton.
Virginia	Washington College	Lexington.
	Institution for Deaf, Dumb and Blind	Staunton.
Wisconsin	Lawrence University	Appleton.
	State University	Madison.

METEOROLOGICAL MATERIAL RECEIVED IN ADDITION TO THE REGULAR OBSERVATIONS.

Anderson, Benj.—Meteorological observations taken during a journey of exploration to the interior, from Monrovia, Liberia, during the year 868.

Barnes, Dr. G. W.—Summary of meteorological observations at Grass Valley, California, during the months of June, July, August, September, and October, 1870.

Barrœta, San Louis Potosi, Mexico.—Thermometrical curves (centigrade) during the first half of April, 1870.

Benton, Rev. A. A.—Meteorological register kept at Kanea, Crete, by Rev. Mr. Benton, missionary of the Protestant Episcopal Board, during he years 1843 and 1844, (part.)

Berendt, Dr. H.—Newspaper cuttings on the climate of Belize, British Honduras.

Board of Commissioners, Central Park, New York.—Thirteenth annual eport, contains general meteorological observations for 1869, and description of observatory.

Boardman, G. A.—Notes on the storm of October 4th and 5th, 1869, at Milltown, Maine.

Boerner, C. G.—Paths of meteors observed during the auroral display of October 24, 1870.

Bruhns, Dr. C.—Meteorologische Beobachtungen, angestellt auf der Leipziger Universitäts-Sternwarte im Jahre 1868. 18vo, 30 pages, 1 Table.

Bullock, T.—Summary of temperature observations at Coalville, Utah, for the year 1869.

Carpenter, P. P., Montreal, Canada.—Account of aurora observed during September, 1870, at Montreal, by Thomas McGinn, (newspaper slip.)

Cazalis, Dr. F.—"Le messager agricole," Montpellier, France, December, 1867, containing meteorological observations made at Montpellier, Departement de Herault.

Cockburn, H.—Notes on British Honduras, (containing meteorological records for Belize, rain-fall from 1862 to 1868 inclusive.)

Crocker, Allen, Burlington, Kansas.—Diagram and description of remarkable halo seen February 5, 1870.

Curtis, A.—Meteorological summary for 1869 at Ashland, Schuylkill County, Pennsylvania.

Daguin, M.—Résumé des observations meteorologiques faites à l'observatoire de Toulouse pendant l'année 1867–'68, par M. Daguin. 8vo, 11 pages; 1868–'69, 8vo, 4 pages.

Daniels, Wm.—Record of weather during the month of July, 1870, at Peru, Miami County, Indiana.

Deem, D.—Diagram of thermometrical and barometrical curves, and snow and rain-fall, for February, 1869, at Knightstown, Indiana. The same for November, 1869, at Mount Hope, Indiana.

Dodd, Professor C. M.—Record of anemometer (Robinson's) at the Indiana State University, during November, 1869.

Dudley, T.—Account of halo seen at Decatur, Illinois, February 5, 1870.

Ewing, C. G.—Meteorological observations at San Francisco, California, during part of the year 1870. (Newspaper slips from Daily Alta California.)

Foster, Captain R. W.—Notes made on a passage through the Straits of Magellan, in the steamship City of Pittsburgh, in the year 1852.

Foster, Capt. R. W., New Orleans.—Journal of the voyage of the steamship Alabama from New Orleans to Vera Cruz in December, 1850.

French, J. B., Agent.—Rain and snow fall record kept by the W. L. C. & W. Manufacturing Company at Laconia, Bristol, and other places in New Hampshire, during 1870.

Gesellschaft Isis, Meissen.—Zusammenstellung der Monats- und Jahresmittel aus den zu Meissen im Jahre 1869.

Government of Victoria, Australia.—Discussion of the meteorological and magnetical observations made at the Flagstaff Observatory, Melbourne, during the years 1858-'63, by Geo. Neumayer, Ph. D. Mannheim, 1867. 4to, 202 pages.

Green, H. A.—Record of weather at Atco, New Jersey, during 1870.

Record of thermometer at Atco, New Jersey, during November and December, 1869.

Haidinger, W. Ritter von.—Ueber das Regenbogen-Phänomen am 28. Juli, 1861. 8vo, 6 pages.

On the phenomena of light, heat, and sound accompanying the fall of meteorites. By W. Ritter von Haidinger. (From Proc. R. S., No. 107, 1868.) 8vo, 6 pages.

Howland, L., United States Consul.—Meteorological observations for the month of May, 1870, at the University of Valencia. (Printed slip.)

James, I. W.—Summary of observations at Marengo, Illinois, during 1870.

Jelinek, Dr. C.—Ueber den jährlichen Gang der Temperatur zu Klagenfurt, Triest, und Arvavalalja. Von Dr. C. Jelinek. 8vo, 39 pages.

Ueber die tägliche und jährliche Periode der relativen Feuchtigkeit in Wien. Von Hans Wittek. 8vo, 13 pages, 2 Tables.

Ueber die jährliche Vertheilung der Gewittertage, nach den Beobachtungen an den meteorologischen Stationen in Oesterreich und Ungarn. Von Dr. C. Jelinek. 8vo, 9 pages.

Jewell, J. Grey, M. D., United States Consul Singapore.—Meteorological observations at Singapore, British East Indies, during the months of May, June, July, August, September, October, November, and December, 1869. By H. Q. Randell, colonial surgeon.

K. K. Centralanstalt für Meteorologie und Erdmagnetismus.—Beobachtungen an der K. K. Centralanstalt für Meteorologie und Erdmagnetismus.

K. K. Sternwarte in Krakau.—Mittlere Temperatur zu Krakau, nach 40-jährigen Beobachtungen, 1826–1865. Von Dr. F. Karlinski. 4to, 14 pages, 1 diagram.

K. K. Sternwarte, Prag.—Magnetische und meteorologische Beobachtungen auf der K. K. Sternwarte zu Prag, im Jahre 1869. 4to, 170 pages.

Knapp, Geo. C.—Meteorological register from January to April, 1869, at Billis, Asia.

Koninklijk Nederlandsch Meteorologisch Instituut.—Nederlandsch meteorologisch Jaarboek voor 1869. Oblong 4to, 262 pages.

Lander, Sam'l, President Davenport Female College.—Meteorological observations taken at the Davenport Female College, Lenoir, North Carolina.

Latham, Dr. H. L.—Notes on the climate of Laramie Plains, Wyoming Territory.

Le Messager Agricole. Revue des associations et des intérêts agricoles du midi. Publié sous la direction de M. le Dr. F. Cazalis.—Contains monthly meteorological tables made at L'École Normale de Montpellier, departement de Herault, France.

Loomis, Professor E.—Comparison of the mean daily range of the magnetic declinations with the number of auroras observed each year, and the extent of the black spots on the surface of the sun. By Elias Loomis, Yale College. 8vo, 19 pages.

Macgregor, C. J., M. A.—On the climatology of Stratford, Ontario. 8vo, 4 pages.

Magnetic Observatory, Toronto.—Monthly meteorological registers, (printed.)

Mapes, H. H.—Monthly manuscript notes on the weather at Oshtemo, Kalamazoo, and other points in Michigan.

Merriam, C. L.—Meteorological comparisons from records kept at Locust Grove, Leyden, Lewis County, New York.

Meteorologische Centralanstalt, Zurich.—Schweizerische meteorologische Beobachtungen.

Meteorological Institute of Norway.—Norske meteorologisk Aarbog, 1868, 2den Aargang. Christiania, 1869. Oblong 4to, 213 pages.

Meteorological Office, London.—Report of the meteorological committee of the Royal Society for the year ending 31st December, 1869. 8vo, 58 pages.

Weather reports from July 1, 1868, to June 30, 1870. 3 volumes, folio; 6 parts unbound.

Quarterly weather report of the Meteorological Office, with pressure and temperature tables, for the year 1869. Part I, January to March, 1869. 4to, 73 pages, 36 plates.

Meteorological Office, Calcutta.—Report of the meteorological reporter to the government of Bengal. Meteorological abstract for the year 1869. By H. F. Blandford, meteorological reporter. Large 8vo, 108 pages.

Meteorological Society, London.—Proceedings.

Miller, Rev. Jas. N.—The true direction and velocity of the wind observed from ships while sailing. By Rev. J. N. Miller. 8vo, 18 pages.

Morris, Professor O. W.—Diagram of temperature, humidity, and barometer, at Cooper Union, New York, during the month of June, 1870. Also summary of meteorological observations for 1868.

Moss, G. B.—Monthly manuscript summaries of meteorological observations at Belvidere, Illinois.

Newspaper slips relating to the meteorology of Northern Illinois.

Muller, Dr. R.—Detailed descriptions of various meteorological phenomena observed at the Theological Seminary, Carthagena, Ohio. (Appendices to regular monthly reports.)

Naturforschende Gesellschaft in Emden.—Das Gesetz der Winde, abgeleitet aus dem Auftreten derselben über Nordwest-Europa. Von Dr. M. A. F. Prestel. Mit einer Karte. 4to, 26 pages.

Nelson, S. A.—Newspaper cuttings in reference to certain storms in Massachusetts in the year 1870.

Newton, E. H.—Range of thermometer at Mount Carmel, Covington County, Mississippi, latitude 31° 34′, longitude 90° 20′ 15″, during the months of January and February, 1870.

Norske Meteorologiske Institutet.—Température de la mer entre l'Irlande, l'Écosse et la Norvege, par H. Mohn, directeur de l'Institut Météorologique de Norvege. Christiania, 1870. 8vo, 16 pages, 5 charts.

Observatoire Impériale, Paris.—Atlas météorologique de l'Observatoire Impériale, année 1867. Large 4to.

Observatorio Marina de San Fernando.—Anales, seccion e observaciones meteorolojicas, 1870. 4to, 32 pages.

Observatoire Meteorologique Central de Montsouris.—Bulletins.

Observatoire Royale de Bruxelles.—Annales météorologiques, 1869. 4to, 96 pages.

Paine, Dr. H. M., Albany, New York.—Newspaper slips giving accounts of meteorological phenomena.

Parvin, Professor T. S.—Meteorological observations for the year 1869. (Printed slips.)

Peelor, D.—Records kept by self-registering barometer at Johnstown, Cambria County, Pennsylvania. Also various notes on meteorological phenomena, newspaper slips, &c.

Pettersen, F.—Record of weather during the years 1868, 1869, and 1870, at San Antonio, Texas.

Plantamour, Professor E.—Résumé météorologique de l'année 1868, pour Génève et le Grand St. Bernard. Génève, 1868. 8vo, 359 pages.

Prestel, Dr.—Der Sturmwarner und Wetteranzeiger, ein nach wissenschaftlichen Grundsätzen ausgeführtes und durch Beobachtungen und Erfahrung bewahrtes Instrument zu Vorherbestimmung von Sturm und Wetter. Von Dr. M. A. F. Prestel. 8vo, 55 pages, 2 Tables.

R. Accademia delle Scienze di Torino.—Bolletino meteorologico ed

astronomico del Regio Osservatorio dell' Università di Torino. Anno IV. 1869. Oblong 4to, 43 pages.

Radcliffe Observatory.—Results of astronomical and meteorological observations, 1867. Oxford, 1870. 8vo, 340 pages.

Rikatcheff, M.—Marche diurne de la température a Barnaul et a Nertchinsk; par M. Rikatcheff. 4to, 23 pages.

Rivett-Carnac, H.—The state of the weather and prospects of the cotton crop in the Central Provinces and the Beracs. Reported to the secretary of the Chamber of Commerce, Bombay, by Harry Rivett-Carnac, esq., cotton commissioner. Large 8vo, 15 pages. August, 1870.

Saickins, J. G.—Monthly tables of meteorological elements, deduced from observations taken at the observatory, Georgetown, Demerara, British Guiana, during eleven years, commencing January, 1846. By Patrick Sandeman, observer. Small 4to, 275 pages.

Sawyer, H., United States Consul.—Meteorological observations at Paramaribo during the year 1869. (Newspaper slip.)

Scottish Meteorological Society.—Journal of the Scottish Meteorological Society.

Sheppard, Smiley.—Monthly manuscript reports of the weather at Hennepin, Illinois.

Simmons, A. H.—Photograph showing effect of southwest wind in January, at Walla-Walla, Washington Territory, in the valley of the Upper Columbia.

Simonin, J. B.—Meteorologie et climat du department de la Muerthe, par J. B. Simonin, père. Nancy, 1862. 8vo, 38 pages.

Stanley, J. H. S.—Monthly manuscript reports of weather at Houston, Texas.

Stewart, Professor W. M.—Account of storm at Nashville, Tennessee, 1870.

Strong, A. M.—Register of meteorological observations at Magnolia, Florida, for April, 1870.

Weather record kept at St. Augustine and Jacksonville, Florida, during the months of December, 1869, and January, February, and March, 1870, by A. M. Strong and Judge Ellwood, of Iowa. Barometer record at Magnolia by Mr. Trott.

Taylor, Horace.—Weather-table observations taken at Canandaigua, New York, during the year 1869.

Trembley, Dr. J. B.—Annual meteorological synopsis for 1869, at Toledo, Ohio. 8vo, 18 pages.

Università di Torino.—Bolletino meteorologico ed astronomico del Regio Osservatorio dell' Università di Torino. Anno IV. 1869. Oblong 4to, 85 pages. Anno III. 1868. Oblong 4to, 20 pages.

Universitäts-Sternwarte, Leipsic.—Uebersicht der Resultate aus den meteorologischen Beobachtungen, angestellt auf den königlich-sächsischen Stationen. 4to, 42 pages.

University of Chile.—Observaciones meteorolojicas, hechas en el observatorio meteorolojica de Santiago, i en el Faro de Valparaiso, en el año de 1866. Por José Vergara. 8vo, 63 pages. 1867. 8vo, 62 pages. 1868. 8vo, 60 pages.

Datos recajidos sobre el terremoto i las ajitaciones del mar, del 13 de Agosto de 1868. Comunicacion de D. Ignacio Domeyko a la faculdad de ciencias fisicas i matematicas en su sesion del 15 de Noviembre del mismo año. Santiago, 1869. Large 8vo, 43 pages.

Useful Knowledge Society, Macclesfield.—Meteorological observations taken at the Useful Knowledge Society rooms, Macclesfield, England. (Printed slips from 1860–'69, inclusive.)

Videnskabsselskabet, Christiania.—Storm-Atlas, udgivet med Bestand af Videnskabsselskabet, Christiania, af H. Mohn. Large folio.

Webster, W. Prentiss, United States Consul General, Frankfurt am Main.—Notes on earthquake felt in Germany during the months of October and November, 1869. (Through the Department of State.)

Whitcomb, G.—Meteorological report for 1869, by Adam Miller, at East Prairie, Mississippi County, Missouri.

Williams, Rev. R. G.—Hourly observations of barometer, psychrometer, and thermometer, together with observations on magnetic variation. (In addition to regular monthly observations on Smithsonian blanks.)

Wilson, L.—Summary of meteorological observations at Astoria, Oregon, for the years 1866–'70. Rain-fall from 1856–'70, inclusive. Monthly means.

Wing, Miss M. E.—Manuscript notes on the weather and meteorological phenomena at West Charlotte, Vermont.

Wislizenus, Dr. A.—Meteorological observations at St. Louis, Missouri, during November and December, 1869; together with the records of atmospheric electricity, &c., from 1861–'69, inclusive.

Zantedeschi, Professor F.—La meteorologia del globo studiata a diversi altitudini da terra. 8vo, 11 pages.

Zentralnaia Fisicheskaia Observatoria, St. Petersburg.—Repertorium für Meteorologie, herausgegeben von der K. Akademie der Wissenschaften; redigirt von Dr. H. Wild. Band I, Heft I. 4to, 242 pages, 5 plates.

Vorschläge betreffend die Reorganisation des meteorologischen Beobachtungs-Systemes in Russland. Bericht einer Commission der Akademie. 8vo, 24 pages.

REPORT OF THE EXECUTIVE COMMITTEE.

The Executive Committee of the Board of Regents respectfully submit the following statement as their report in relation to the funds of the Institution, the receipts and expenditures for the year 1870, and the estimates for the year 1871.

Statement of the fund at the beginning of the year 1871.

The amount originally received as the bequest of James Smithson, of England, deposited in the Treasury of the United States, in accordance with act of Congress of August 10, 1846	$515,169 00
The residuary legacy of Smithson received in 1865, deposited in the Treasury of the United States, in accordance with the act of Congress of February 8, 1867	26,210 63
Total bequest of Smithson	541,379 63
Amount deposited in the Treasury of the United States, as authorized by act of Congress of February 8, 1867, derived from savings of income and increase in value of investments	108,620 37
Total permanent Smithson fund in the Treasury of the United States, bearing interest at 6 per cent., payable semi-annually in gold	650,000 00
In addition to the above there remains of the extra fund derived from savings, &c., in Virginia State registered 6 per cent. bonds, at par value, $72,760, now valued at	48,000 00
Total investments	698,000 00
Balance on hand January, 1871, of uninvested funds	21,477 81
Total of the Smithson fund, January, 1871	719,477 81

Receipts for 1870.

Interest for 1870 on $650,000, at 6 per cent. in gold	$39,000 00
Premium on $39,000 gold, at 11¾ and 10⅝ per cent.	4,363 12
Cash from a friend of science, in aid of publications	1,200 00
Sale of publications	360 52
Sale of useless materials	64 87
Repayment of expenses of explorations	68 40
Repayment of freight and postage	432 47
Total receipts for the year	45,489 38

Expenditures for 1870.

Building and furniture	$4,843 13	
General expenses	14,840 65	
Publications and researches	15,873 22	
Museum and exchanges	9,424 22	
Total expenditures for the year		44,981
Balance		508

Besides this balance of $508 16, there was a balance of $20,969 65 in bank, at the beginning of 1870, which makes the total uninvested and available balance mentioned in the general statement of $21,47

In addition to the receipts mentioned above, the Institution rece from and accounted to the Interior Department for $5,024, being of the $10,000 appropriated by Congress for the preservation and during the year ending June 30, 1871, of the specimens collecte various exploring expeditions. This sum is not included in the acc of expenditures.

Statement in detail of expenditures—1870.

BUILDING.

For reconstruction of parts of building	$860 12	
For general repairs of building	3,852 81	
For furniture and fixtures, cases, carpets, stoves, &c	130 20	
		$4,84

GENERAL EXPENSES.

For meetings of the Board of Regents	$178 25	
For lighting the building	355 42	
For warming the building	1,566 22	
For postage	770 98	
For stationery	829 19	
For printing blanks, circulars, receipts, &c	389 13	
For tools, materials for cleaning and incidentals	478 16	
For salaries of Secretary, clerks, and assistants	10,273 30	
		14,84

PUBLICATIONS AND RESEARCHES.

For publishing Smithsonian contributions, 4to.	$6,986 57	
For publishing miscellaneous collections, 8vo..	3,065 37	
For publishing Smithsonian reports, 8vo.....	283 45	
For meteorology, salaries of clerk and computers, and for thermometers and rain-gauges..	3,119 00	
For apparatus for researches.....	249 70	
For explorations, natural history, and archæology	1,414 13	
Lectures	755 00	
		$15,873 22

MUSEUM AND EXCHANGES.

For literary and scientific exchanges, through agencies at Leipsic, London, Paris, Amsterdam, &c.....	$4,165 62	
For museum, salary of assistant secretary and assistants in museum, and for incidentals in addition to the appropriation from Congress.	5,008 84	
For purchase of books, periodicals, &c.....	249,76	
		9,424 22
Expenditures during 1870		44,981 22

Estimated receipts for 1871.

From interest on Smithson fund, in Treasury of the United States	$39,000 00
Probable premium on gold, 10 per cent. on the above $39,000	3,900 00
Sale of books, &c	1,000 00
Total	43,900 00

Estimated appropriations for 1871.

For general expenses.....	$10,000 00
For publications, researches, &c.....	20,000 00
For exchanges.....	5,000 00
For purchase of books and apparatus	2,400 00
For museum, (additional to congressional appropriation) ..	1,500 00
For steam heating-apparatus fund.....	5,000 00
Total	43,900 00

Besides the above estimated receipts, there is in bank, as before stated in the general account, the sum of $21,477 81.

The committee have examined six hundred and twenty-one receipted vouchers for payments made during the four quarters of the year 1870. In every case the approval of the Secretary of the Institution is given on each voucher, and the certificate of an authorized agent of the Institution is appended, setting forth that the materials and property and services rendered were for the Institution, and to be applied to the purposes stated in the account.

The quarterly accounts-current, bank-book, check-book and ledger were also examined and found to be correct, showing a cash balance in bank on January 1, 1871, of $21,477 81.

All of which is respectfully submitted.

PETER PARKER,
JOHN MACLEAN,
Executive Committee.

JANUARY 26, 1871.

JOURNAL OF PROCEEDINGS

OF

THE BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION.

WASHINGTON, *May* 23, 1870.

ieeting of the Board of Regents was held this evening, at the call
Secretary. Present: Hon. L. P. Poland, Hon. L. Trumbull, Hon.
Garfield, Hon. S. S. Cox, General Delafield, Hon. Peter Parker,
Dr. J. Maclean, and Professor Henry, the Secretary.
the absence of the Chancellor, Judge Poland was called to the

Secretary presented the report of the expenditures on account of
overnment collections for the year 1869; and, on motion of General
ld, it was resolved that the Board of Regents apply to Congress
appropriation of $10,000 for the care of the Government collec-
luring the year 1870.
fessor Henry stated that the resolution of the board adopted at
eeting of February 3, 1870, authorizing him to visit Europe, had
ntirely unexpected to him, as he had received no intimation pre-
to its being offered that it was in contemplation; that he had con-
l to avail himself of the resolution, and that he was making prepa-
s for his departure on the 1st of June; that he intended to make
gements for the operations of the Institution which were to be
l on during his absence; that he intended to settle all the accounts
would be due at the time of his departure; to deposit checks for
laries accruing during his absence, to be paid on the indorsement
fessor Baird; and also to deposit to the credit of that officer $2,000,
transportation and incidental expenses; that he had been much
ed with the expressions of kind feeling which had been called
by the announcement of his intended visit to Europe, and the
which he had received from the Cunard and Bremen lines of
ers of a free passage across the ocean.
board then adjourned.

WASHINGTON, *January* 18, 1871.

ccordance with a resolution of the Board of Regents of the Smith
Institution, *fixing the time of* the beginning of their annual meet-

WASHINGTON, *March* 9, 1871.

A meeting of the Board of Regents was held this evening at 7 o'clock. Present: Hon. H. Hamlin, Hon. L. P. Poland, Hon. S. S. Cox, Hon. P. Parker, General W. T. Sherman, and the Secretary, Professor Henry.

Judge Poland was called to the chair.

The minutes of the last meeting were read and approved.

The Secretary stated that by joint resolution of Congress, Genera William T. Sherman had been elected a Regent for the term of six years, *vice* Richard Delafield, resigned.

On motion of Mr. Hamlin, the vacancy existing in the executive committee was filled by the election of General Sherman.

The Secretary called attention to the fact that the mayor of the city of Washington was *ex officio* a Regent, but that under the new territorial government the office of mayor ceased, and suggested the propriety of action by Congress to substitute the governor of the Territory as the *ex officio* member of the board.

Messrs. Hamlin and Poland expressed their intention to bring the subject before Congress immediately, and anticipated no objection to the passage of an act providing for the change contemplated.

The Secretary gave an account of the improvements now being made in the building under the appropriation by Congress. The new hall would soon be finished, and it was proposed to devote it mainly to ethnology. Mr. B. Waterhouse Hawkins had been employed to prepare illustrations of extinct animals, &c., to decorate the walls.

The Secretary called attention to the books belonging to James Smithson, the founder of the Institution, and requested some action in relation to the best manner of their preservation. It was thought proper to preserve them in a metallic case with plate-glass front, open to the view of the public, but not to be taken out by any one.

The Secretary presented his annual report for 1870, which was read and accepted.

The board then adjourned *sine die*.

GENERAL APPENDIX

TO THE

SMITHSONIAN REPORT FOR 1870.

The object of this Appendix is to illustrate the operations of the Institution by reports of lectures and extracts from correspondence, as well as to furnish information of a character suited especially to the meteorological observers and other persons interested in the promotion of knowledge.

EULOGY ON PROF. ALEXANDER DALLAS BACHE,
LATE SUPERINTENDENT OF THE UNITED STATES COAST SURVEY.

By Prof. Joseph Henry.

Prepared at the request of the Board of Regents of the Smithsonian Institution, and also of the National Academy of Sciences.

Alexander Dallas Bache, whose life and character form the subject of the following eulogy, was the son of Richard Bache, one of eight children of Sarah, the only daughter of Dr. Benjamin Franklin. His mother was Sophia Burret Dallas, daughter of Alexander J. Dallas, and sister of George M. Dallas, whose names are well known in the history of this country, the former as Secretary of the Treasury, and the latter as Vice-President of the United States, and subsequently as minister to the Court of St. James.

The subject of our sketch was born in Philadelphia, on the 19th of July, 1806. At an early age he became a pupil of a classical school, and was distinguished by an unusual aptitude in the acquisition of learning. Shortly before arriving at the age of fifteen he was appointed a cadet at the National Military Academy at West Point. Here, though the youngest pupil, he soon attained a high grade of scholarship, which he maintained during the whole of his course, and was finally graduated in 1825, at the head of his class. His merit was in this case the more conspicuous, inasmuch as the class is shown to have been one of unusual ability, by having numbered no less than four successful candidates for the honor of adoption into the Corps of Engineers. It has been mentioned as a solitary instance in the history of the Academy, noted for its rigid discipline, that young Bache passed through the entire course of four years without having received a mark of actual demerit, and, what is perhaps not less uncommon, without having called forth the least manifestation of envy on the part of his fellow-pupils. On the contrary, his superiority in scholarship was freely acknowledged by every member of his class, while his unassuming manner, friendly demeanor, and fidelity to duty secured him the affection as well as the respect of not only his fellow-pupils, but also of the officers of the institution. It is also remembered that his classmates, with instinctive deference to his scrupulous sense of propriety, forbore to solicit his participation in any amusement which in the slightest degree conflicted with the rules of the Academy. So far from this, they commended his course, and took pride to themselves,

as members of his class, in his reputation for high standing and exemplary conduct. His room-mate, older by several years than he was, and by no means noted for regularity or studious habits, constituted himself, as it were, his guardian, and sedulously excluded all visitors or other interruptions to study during the prescribed hours. For this self-imposed service, gravely rendered as essential to the honor of the class, he was accustomed jocularly to claim immunity for his own delinquencies or shortcomings. But whatever protection others might require on account of youth and inexperience, young Bache needed no guardian to keep him in the line of duty. Impressed beyond his years with a sense of the responsibility which would devolve upon him as the eldest of his mother's family, entertaining a grave appreciation of the obligations involved in his education at the National Academy, he resolved from the first to exert his energies to the utmost in qualifying himself for the duties which he might be called upon to discharge, whether in professional or private life. Nor was he uninfluenced in this determination by a consciousness that as a descendant of Franklin he was, in a certain degree, an object of popular interest, and that on this account something more than an ordinary responsibility rested upon him. On a mind constituted like his an influence of this kind could not but exert a happy effect.

The character which he established for gentleness of manner and evenness of temper was not entirely the result of native amiability, for when a child he is said to have been quick-tempered, and at later periods of his life, when suddenly provoked beyond his habitual power of endurance, he sometimes gave way to manifestations of temper which might have surprised those who only knew him in his usual state of calm deportment. These ebullitions were, however, of rare occurrence, and always of short duration. His marked characteristic was the control which he had acquired over his passions and feelings, and it was this which enabled him to suppress all tendency to self-indulgence, to pursue with unremitting perseverance the course he had marked out, to observe an undeviating regard for truth and justice, and to cherish habitually all that would tend to exemplify the kindlier affections of the heart.

Although young Bache was perhaps predisposed, from hereditary influence, to form correct habits and adopt high moral principles, yet these dispositions might have remained dormant had it not been for the early training and the watchful care of his noble mother. From his earliest days she checked with gentle reproof every indication of childish revolt against wholesome restraint, and steadily carried out her system of discipline so gently and yet so effectually that it met with scarcely any opposition, and left the conviction that she was always in the right. Her maternal solicitude did not end with his being placed under military rule, but was continued through his whole course by means of a ready pen. In the language of one who was permitted to

read her letters to her son while at West Point, "nothing could be more admirable than the way in which, amid pleasant gossip and family news, she would inspire her son with high sentiments and encourage him to persevering industry."

As an illustration of his persistency of purpose, it is related that, when a recitation of more than common length or difficulty was to be prepared for the morrow, it was no unusual practice of his to place himself on a seat of unstable equilibrium, which by giving way when volition was about to lose its power recalled his flagging attention to the allotted task.

After graduating he was selected, on account of his scholarship, to remain at the Academy as an assistant professor. In this position, which gave him an opportunity to review his studies and extend his reading, he continued one year; when, at his own request, he was assigned to engineering duty under the late General, then Colonel, Totten, at Newport, Rhode Island. Here he remained two years, engaged in constructing fortifications, devoting his extra hours to the study of physics and chemistry, and, as a recreation, collecting and labeling the shells of that region. But the most important event of this period of his life, and that which, doubtless, contributed in a large degree to his future success, was his becoming acquainted with and subsequent betrothal to Miss Nancy Clarke Fowler, the daughter of an old and highly-respected citizen of Newport. With the stinted pay of a lieutenant of engineers, out of which his mother and her younger offspring were to be provided for, marriage was not to be thought of, excepting as an event in the remote distance. Fortunately as unexpectedly, however, a change now took place in his circumstances which enabled him to gratify the earnest wish of his heart and to secure to himself a companion and helpmate who lavished upon him all her affections, and through his life ardently devoted all her thoughts and energies to sustain, assist, and encourage him. The change alluded to, and which opened to him an uninterrupted career of usefulness during the whole of his active life, was the result of an invitation to the chair of natural philosophy and chemistry in the University of Pennsylvania, at Philadelphia. He accepted the position with that unaffected diffidence which is the usual concomitant of true but untried merit, though, as might have been anticipated, his eventual success was commensurate with the industry and ability which had marked his previous progress. Having already had some experience as a teacher, he the more readily gained the entire confidence of the authorities of the university and the affection of his pupils. He did not, however, rest satisfied with the occupation of teacher, or with merely imparting knowledge obtained by the labors of others, but sought to enlarge the bounds of science by discoveries of his own. As auxiliary to this, he became a member of the Franklin Institute, a society then newly established for the promotion of the mechanical arts. This society, which still maintains a vig-

orous existence, was well calculated to exhibit his talents and develop his character. It brought him into intimate association with the principal manufacturers, engineers, and artisans of the city, and into relations of friendship with a large number of young men destined, in more advanced life, to exert an extended influence on public affairs. He was appointed chairman of one of the most important of its committees, and was chosen as the expounder of the principles of the institute at its public exhibitions. Facilities were thus afforded him for the prosecution of science, which he could not have well commanded in any other position. Workshops were thrown open to him, and skillful hands yielded him ready assistance in realizing the conceptions of his suggestive mind. His descent from the illustrious statesman and philosopher whose name the institute bears, and who is almost regarded as the tutelar saint of Philadelphia, no doubt contributed to a prepossession in his favor, but the influence which he acquired and maintained was due to his own learning, industry, ability, and courtesy. To these he owed the favor and distinction of having conferred upon him the principal directorship of the scientific investigations of the institute, and the opportunity which it afforded him of so greatly contributing to the usefulness of the society and to the advancement of his own reputation.

For a full account of the labors in which he was engaged in his connection with the Franklin Institute we must here be content with referring to the volumes of its journal from 1828 to 1835 inclusive. We may pause a moment, however, to notice the investigations relating to the bursting of steam-boilers, of which he was the principal director. The public mind had, at that epoch, been so frequently and painfully called to this subject that the institute was induced to organize a series of systematic researches in regard to it, the importance of which was soon recognized by the General Government in the form of an appropriation for defraying the attendant expenses. In the prosecution of these inquiries a large amount of information relative to explosions, and suggestions as to their causes, was first collected by correspondence, and on this was based a series of well-devised experiments, which were executed with signal address, and the results interpreted with logical discrimination. The conclusions arrived at were embodied in a series of propositions, which, after a lapse of more than thirty years, have not been superseded by any others of more practical value. The most frequent cause of explosion was found to be the gradual heating of the boiler beyond its power of resistance; and next to this, the sudden generation of steam by allowing the water to become too low, and its subsequent contact with the overheated metal of the sides and other portions of the boiler. The generation of gas from the decomposition of water as a cause of explosion was disproved, as was also the dispersion of water in the form of spray through superheated steam. These experiments were not unattended with danger, and required, in their execution, no small amount of personal courage. Accidents were immi-

nent at almost every stage of the investigation; and in some instances explosions were produced which alarmed the neighborhood. So true is it that in the pursuit of science dangers are oftentimes voluntarily encountered, exacting no less courage or firmness of nerve than that which animates the warrior in the more conspicuous but scarcely more important conflicts of the battle-field.

The attention of Mr. Bache at this period was not exclusively devoted to his labors in connection with the Franklin Institute. He was also a member of the American Philosophical Society, and, as such, in association with Hare, Espy, and others interested in the pursuit of various branches of physics and chemistry. He erected an observatory in the yard of his dwelling, in which, with the aid of his wife and of his former pupil, John F. Fraser, he determined with accuracy, for the first time in this country, the periods of the daily variations of the magnetic needle, and by another series of observations the connection of the fitful variations of the direction of the magnetic force with the appearance of the aurora borealis.

Again, in connection with his friend, Mr. Espy, he made a minute survey of a portion of the track of a tornado, which visited New Brunswick, in New Jersey, on the 19th of June, 1835, and from the change of place and relative position of the trees and other objects, as left by the wind, he succeeded in establishing the fact, in accordance with the hypotheses of Mr. Espy, that the effects of the storm were due to an ascending and progressive column of air, by which all objects within the influence of the disturbance, on either side the track, were drawn inward, and not due, as had been supposed, to a horizontal rotation at the surface, which would tend to throw them outward by centrifugal projection. In coöperation with Professor Courtenay, he also made a series of determinations of the magnetic dip at various places in the United States. Indeed, terrestrial magnetism was with him a favorite subject, to which he continued to make valuable contributions at intervals during his whole life. The phenomena of heat likewise engaged much of his attention, and he was the first to show, contrary to generally-received opinion, that the radiation and consequent absorption of dark heat is not affected by color. His investigations in this line were suddenly brought to a close by an accident, which we may be allowed to mention as furnishing an illustration of his self-control and considerate regard for the feelings of others. After an expenditure of money which he could ill afford, and of time withdrawn from the hours due to repose, he had procured and arranged on a stand a series of delicate instruments intended for a long-meditated experiment on radiant heat. During his temporary absence his mother, in hurriedly passing through the apartment, accidentally caught in her dress the support of the apparatus and brought the whole to the floor, a mass of mingled fragments. The author of this disaster was so painfully affected by the destruction, of which she had been the unintentional cause, as to be

with which it abounds. The accounts which are given of the different schools of Europe are founded on personal inspection; the results being noted down at the time with the writer's habitual regard to accuracy.

After completing his report he was prepared to commence the organization of the Girard College, but the trustees, partly on account of the unfinished condition of the building, and partly from a delay in the adjustment of the funds of the endowment, were not disposed to put the institution into immediate operation. In the mean time Professor Bache, desirous of rendering the information he had acquired of immediate practical use, offered his services gratuitously to the municipal authorities of Philadelphia, to organize, on an improved basis, a system of public education for that city. This offer was gladly accepted, and he commenced the work with his usual energy and with the cordial support of the directors and teachers of the common schools. At the end of the year, finding that the trustees of the college were still unprepared to open the institution, he relinquished the salary, but retained the office of president, and devoted his time mainly to the organization of the schools. He was now, however, induced to accept from the city, as the sole and necessary means of his support, a salary much less than the one he had relinquished. The result of his labors in regard to the schools was the establishment of the best system of combined free education which had, at that time, been adopted in this country. It has since generally been regarded as a model, and has been introduced as such in different cities of the Union.

In 1842, having completed the organization of the schools, and Girard College still remaining in a stationary condition, he resigned all connection with it, and, yielding to the solicitations of the trustees of the university, returned to his former chair of natural philosophy and chemistry, in order that he might resume the cultivation of science. Not that it is to be inferred that in his devotion to the advancement of education he had relinquished or deferred the scientific pursuits to which the habit of his mind and the bent of his genius continually impelled him, for during his travels in Europe he had been careful to provide himself with a set of portable instruments of physical research, and, as a relief from the labors imposed by the special object of his mission, he instituted a connected series of observations at prominent points on the Continent and in Great Britain, relative to the dip and intensity of terrestrial magnetism. These observations were made with the view of ascertaining the relative direction and strength of the magnetic force in Europe and America, by the comparison of parallel series of observations in the two countries with the same instruments. They also served, in most instances, to settle with greater precision than had previously been attained the relative magnetic condition of the points at which they were made.

Though the organization of the schools of such a city as Philadelphia might seem sufficient to absorb all his energy and self-devotion, yet

even in the midst of this labor we find our late colleague actively coöperating in the great enterprise of the British Association to determine by contemporaneous observations, at widely separated points, the fluctuations of the magnetic and meteorological elements of the globe. This coöperation, in which no doubt a feeling of national pride mingled itself with his ardor for the advancement of science, consisted primarily in the establishment of an observatory, to which the trustees of Girard College contributed a full series of instruments, combining all the latest improvements, and which was supported by the American Philosophical Society, and a number of liberal and intelligent individuals. The observations which were here continued at short intervals, both by day and night, for five years, form a rich mine of statistics, from which, until within the last few years of his life, the professor drew a highly interesting series of results, without exhausting the material. In addition to these observations, he made during his summer vacations a magnetic survey of Pennylvania.

He was not destined to remain long in his old position in the university. Before he had become fairly settled in it and had renewed his familiarity with its duties, he was called in November, 1843, on the occasion of the death of Mr. Hassler, Superintendent of the United States Coast Survey, to fill the important sphere of public duty thus rendered vacant. His appointment to this position was first suggested by the members of the American Philosophical Society, and the nomination fully concurred in by the principal scientific and literary institutions of the country. In this movement he himself took no part, and indeed regarded the position as one not to be coveted; for while it opened a wide field for the exercise of talent and the acquisition of an enviable reputation, it involved responsibilities and presented difficulties of the gravest character. Professor Bache was not one of those who, abounding in self-confidence, imagine themselves equal to every exigency, or who seek the distinctions and emoluments of office without any regard to the services to be rendered or the duties to be discharged. On the contrary, though early and continued success must have tended to increase his self-esteem, each new position to which he was called was entered upon with feelings of solicitude rather than of exultation. He rightly judged that the proper moment for self-congratulation is not at the beginning of an arduous and precarious enterprise, but at the time of its full and successful accomplishment. Nor can it be necessary to add that this characteristic contributed largely to his success. In civil service as in the camp, the leader to whom all look with confidence is not he who, with blind and arrogant self-reliance, disdains caution as unworthy of courage, but he who, sensitively alive to the dangers to be encountered, exerts every faculty in calling to his aid every resource which may tend to secure victory or facilitate retreat.

With whatever misgivings Professor Bache may have undertaken the task to which he was assigned, it may be truly said that no living

man was so well qualified as himself to secure the results which the nation and its commercial interests demanded. His education and training at West Point, his skill in original investigations, his thorough familiarity with the principles of applied science, his knowledge of the world, and his gentlemanly deportment, were all in a greater or less degree essential elements in the successful prosecution of the survey. It would appear as if the training and acquisition of every period of his life, and the development of every trait of his character, had been especially ordained to fit him in every respect to overcome the difficulties of this position. Besides the qualifications we have enumerated, he possessed rare executive ability, which enabled him to govern and guide the diverse elements of the vast undertaking with consummate tact and skill. Quick to perceive and acknowledge merit in others, he rapidly gathered around him a corps of men eminently well qualified for the execution of the tasks to which he severally assigned them.

The Coast Survey had been recommended to Congress by President Jefferson as early as 1807, but it was not until ten years afterward that the work was actually commenced, under the superintendence of Professor Hassler, an eminent Swiss engineer, whose plans had been previously sanctioned by the American Philosophical Society. Though the fundamental features of the survey had been established on the most approved scientific principles yet so frequent were the changes in the policy of the Government, and so limited were the appropriations, that, even up to the time of Professor Bache's appointment, in 1843, little more than a beginning had been made. The survey, so far as accomplished, extended only from New York Harbor to Point Judith, on the east coast, and southward to Cape Henlopen. The new Superintendent saw the necessity of greatly enlarging the plan, so as to embrace a much broader field of simultaneous labor than it had previously included. He divided the whole coast line into sections, and organized, under separate parties, the essential operations of the survey simultaneously in each. He commenced the exploration of the Gulf Stream, and at the same time projected a series of observations on the tides, on the magnetism of the earth, and the direction of the winds at different seasons of the year. He also instituted a succession of researches in regard to the bottom of the ocean within soundings, and the forms of animal life which are found there, thus offering new and unexpected indications to the navigator. He pressed into service, for the determination of the longitude, the electric telegraph; for the ready reproduction of charts, photography; and for multiplying copper-plate engravings, the new art of electrotyping. In planning and directing the execution of these varied improvements, which exacted so much comprehensiveness in design and minuteness in detail, Professor Bache was entirely successful. He was equally fortunate, principally through the moral influence of his character, in impressing upon the Government, and especially upon Congress, a more just estimate of what such a survey required for its maintenance and

creditable prosecution. Not only was a largely-increased appropriation needed to carry out this more comprehensive plan, but also to meet the expenses consequent upon the extension of the shore-line itself. Our sea-coast, when the survey commenced, already exceeded in length that of any other civilized nation, but, in 1845, it was still more extended by the annexation of Texas, and again, in 1848, by our acquisitions on the Pacific. Professor Bache was in the habit of answering the question often propounded to him by members of Congress, "When will this survey be completed?" by asking, "When will you cease annexing new territory?" a reply not less significant at the present day than when it was first given, and which may continue long to be applicable under the expansive tendencies of our national policy.

When Professor Bache took charge of the survey, it was still almost in its incipient stage, subjected to misapprehension, assailed by unjust prejudice, and liable, during any session of Congress, to be suspended or abolished. When he died, it had conquered prejudice, silenced opposition, and become established on a firm foundation as one of the permanent bureaus of the executive Government. The importance of the work, which was always highly appreciated by the mariner, became strikingly obvious to the general public through the service which it rendered during the late war, in furnishing accurate charts and sailing directions for the guidance of our squadrons along the southern coast. Nor was this alone; an active participation was also borne by the officers of the survey in the attack of the United States Navy on Sumter, Port Royal, Fort Fisher, Mobile, New Orleans, and other strongholds, while constant aid was rendered by them in the navigation of the inlets and channels, and in the avoidance of hidden rocks or shoals with which none could be more minutely acquainted. Though the value of the survey was signally conspicuous on these occasions, it needs but little reflection to be convinced of its essential connection with the general prosperity of the country. Whatever diminishes the danger of departure from or an approach to our shores facilitates commerce, and thus renders more valuable the products of our industry, even in portions of our land most remote from the sea-board. But the survey should not be viewed alone in its economical relations, since, as an enlightened and liberal people, we owe it to the great community of nations and the cause of humanity to supply the world with accurate charts of our precarious coast, as well as to furnish it with all the other aids to safer navigation which the science and experience of the age may devise.

Professor Bache, with his enlightened appreciation of the value of abstract science, kept constantly in view the various problems relative to the physics of the globe, which are directly or even incidentally connected with the survey of the coast, and ever cherished the hope of being permitted to complete his labors by their solution. Among these was a new determination of the magnitude and form of the earth, and the variations in the intensity of terrestrial gravity at various points on

the continent of North America; the discussion of the general theory of the tides; the magnetic condition of the continent; and the improvement of the general map of the United States, by determining its relation to the coast line, and the precise geographical positions of the most important points in the interior. Though his hopes in regard to these problems were not destined to be realized by himself, fortunately for the cause of science they have been left in charge of a successor in the person of his ardent friend and collaborator. Professor Peirce, to whose genius and industry we may confidently look for that full exposition of the work which, while it entitles him to the highest approbation of the scientific world, will render ample justice to the labors and sagacity of his lamented predecessor.

Besides having charge of the Coast Survey, Professor Bache was Superintendent of Weights and Measures, and in the exercise of this function directed a series of investigations relative to the collection of excise duties on distilled spirits, and likewise superintended the construction of a large number of sets of standard weights and measures for distribution among the several States of the Union. He was also appointed one of a commission to examine into the condition of the light-house system of this country, and to report upon any improvements calculated to render it more efficient. In the investigations pertaining to this subject, involving, as they do, a knowledge of a wide range of applied science, he took a lively interest, and rendered important service in the organization of the admirable system which was adopted and still remains in operation. This commission of investigation was afterward merged in the present Light-House Board, of which he continued a member until the time of his death.

In 1846 he had been named in the act of incorporation as one of the Regents of the Smithsonian Institution, and by successive reëlection was continued by Congress in this office until his death, a period of nearly twenty years. To say that he assisted in shaping the policy of the establishment would not be enough. It was almost exclusively through his predominating influence that the policy which has given the institution its present celebrity was, after much opposition, finally adopted. The object of the donation, it will be remembered, had been expressed in terms so concise that its import could scarcely be at once appreciated by the general public, though to the cultivators of science, to which class Smithson himself belonged, the language employed failed not to convey clear and precise ideas. Out of this state of things it is not surprising that difference of opinion should arise respecting the proper means to be adopted to realize the intentions of the founder of the institution. Professor Bache with persistent firmness, tempered by his usual moderation, advocated the appropriation of the proceeds of the funds principally to the plan set forth in the first report of the Secretary, namely, of encouraging and supporting original research in the different branches of science. Unfortunately this policy could only be

partially adopted, on account of the restrictions of the enactment of Congress, by which provision was to be made for certain specified objects. He strenuously opposed the contemplated expenditure of a most disproportionate sum in the erection and maintenance of a costly edifice; but failing to prevent this, he introduced the resolution adopted by the board as a compromise, whereby the mischief which he could not wholly avert might at least be lessened. This resolution provided that the time of the erection of the building should be extended over several years, while the fund appropriated for the purpose, being in the mean time invested in a safe and productive manner, would serve in some degree to counterbalance the effect of the great and unnecessary outlay which had been resolved on. It would be difficult for the secretary, however unwilling to intrude anything personal on this occasion, to forbear mentioning that it was entirely due to the persuasive influence of the professor that he was induced, almost against his own better judgment, to leave the quiet pursuit of science and the congenial employment of college instruction to assume the laborious and responsible duties of the office to which, through the partiality of friendship, he had been called. Nor would it be possible for him to abstain from acknowledging with heart-felt emotion that he was from first to last supported and sustained in his difficult position by the fraternal sympathy, the prudent counsel, and the unwavering friendship of the lamented deceased.

His demeanor in the board was quiet and unobtrusive, and his opinions sought no support in elaborated or premeditated argument; but when a topic likely to lead to difficulty in discussion was introduced, he seldom failed, with that admirable tact for which he was always noted, to dispose of it by some suggestion so judicious and appropriate as to secure ready acquiescence and harmonious action. The loss of such a man in the councils of the Institution, when we consider the characteristics which it has been our aim to portray, must, indeed, be regarded as little less than irreparable.

As a vice-president of the United States Sanitary Commission his influence was felt in selecting proper agents, and suggesting efficient means for collecting and distributing the liberal contributions offered for ameliorating the condition of our soldiers during the war. But the services which he rendered the Government during the recent struggle were not confined to this agency, or to the immediate operations of the Coast Survey. He was called into consultations to discuss plans of attack on the part of the Navy, and for its coöperation with the Army. He acted also as a member of a commission to which various projects, professing to improve the art of war, were referred, and in this capacity it is not too much to say that his judicious counsel contributed to save the Government millions of dollars by preventing the adoption of plausible though impracticable propositions from which nothing but failure and loss could have resulted.

One of the last acts of his life was an exemplification of the devoted

affection which he had always borne to his native city, whither it was his cherished intention to return when he should be at last released from official duty. At the request of the governor of Pennsylvania, although overwhelmed with other public labors, he planned lines of defenses for Philadelphia, and to a certain extent personally superintended their construction. Unaccustomed for many years to direct exposure to the sun, this work proved too much for his physical strength and brought on the first indications of that malady which terminated his life. Though apparently of a vigorous constitution, and capable, under the excitement of official life, of bearing an unusual amount of bodily fatigue, yet he was subject at intervals to "sick headaches," a disease which seems to have been hereditary, and which perhaps conspired with other causes in terminating his useful and distinguished career. Previous to the war he had spent the warmer part of each summer in a tent, at some point of the primary triangulation of the survey, whence he directed the various parties in the field by correspondence; and as the point was usually at the top of a mountain, or at some elevated position, from which other stations of the survey could be seen, he did not want for invigorating air. With this, and the exercise of measuring angles he laid in a store of health sufficient to enable him to carry on without interruption the arduous duties of the remaining portion of the year. But after the commencement of the war his presence was continually required in Washington to give advice and information as to military and naval operations, and to attend the meetings of the scientific commission to which we have previously referred. He was, therefore, no longer able to avail himself of the recuperating influence of mountain air, and in view of this his valuable life may be said to have been one of the sacrifices offered for the preservation of the Union. The first indications of the insidious disease which gradually sapped the citadel of life were numbness in the fingers of his right hand, and, on one occasion, for a short time only, loss of memory. Though these symptoms gave him some uneasiness, they did not diminish his exertions in the line of his duty. Other symptoms, however, exhibited themselves, which, though awaking anxiety, did not much alarm his friends, until he was suddenly deprived, in a considerable degree, of the power of locomotion and of the expression of ideas; the result, it was supposed, of a softening of the brain. But though the power of expression was paralyzed, his memory appeared to retain all the impressions of the past, and he evidently took much pleasure in having recalled to him scenes and events of years gone by. For several months he was very anxious as to the business of the Coast Survey, and it was with difficulty he could be restrained from resuming in full the duties of his office; but as the malady increased his perception of external objects diminished. He took less and less interest in passing events, and finally seemed to withdraw his attention from the exterior world, with which he almost ceased thenceforth to hold any active communication. It was hoped that a voyage to Europe, through the excitements of shipboard

and the revival of old associations, would be of service to him; but, notwithstanding an occasional manifestation of his wonted spirit of social and intellectual enjoyment at the encounter of a friend of former times or distinguished associate in the walks of science, he returned from a sojourn abroad of eighteen months without having experienced any permanent abatement in the progress of his malady. He lingered for a short time longer, and finally resigned his breath at Newport, Rhode Island, on the 17th of February, 1867, in the sixty-first year of his age.

It would be impossible to name an American distinguished on purely scientific grounds to whom the enlightened sentiment of his own countrymen and of foreign nations has awarded more emphatic marks of admiration and esteem. The degree of Doctor of Laws was conferred on him by the principal universities of this country, and few of our leading societies were willing to forego the honor of numbering him among their associates. He was elected in succession president of the American Philosophical Society, of the American Association for the Advancement of Science, and, of the National Academy of Sciences established by Congress. Nor were foreigners less forward in acknowledging his merit. He was a member of the Royal Society of London, of the Imperial Academy of Sciences at St. Petersburg, of the Institute of France, the Royal Society of Edinburgh, the Royal and Imperial Geographical Society of Vienna, the Royal Academy of Turin, the Mathematical Society of Hamburg, the Academy of Sciences in the Institute of Bologna, the Royal Astronomical Society of London, and of the Royal Irish Academy of Dublin. In addition to these testimonies of appreciation, several medals were awarded to him by foreign governments for his distinguished services in the Coast Survey and in the cause of science generally.

The life we have here sketched is eminently suggestive, both from a philosophical and a practical point of view. It presents an unbroken series of successful efforts, with no interruptions in its sustained and constantly ascending course; all parts follow each other in harmonious continuity; and not only is each stage of its progress in advance of the one which preceded it, but it furnishes the means of education for that which succeeded. It is not merely curiosity, laudable as that might be, but a sense of the importance of the inquiry, which prompts us to ask, What were the mental and moral characteristics of the mind which produced such results? And we say intentionally, the *mind which produced these results*, for although it be true that accident has in many cases a determining influence on the fortunes of an individual, it will be clear from what precedes, or we shall have greatly failed in the task which we proposed to ourselves, that the element of casualty had but little to do with the success which crowned the life to which the question at present relates.

From long acquaintance with him and critical study of the events of

his life, and the distinctive manifestations of his moral and intellectual nature, we venture, though not without hesitation, to present the following analysis of the character of one who has performed so conspicuous a part, and in whose memory so many are deeply interested.

Alexander Dallas Bache possessed, or we may perhaps say originally inherited, a mind of strong general powers, with no faculty in excess or in deficiency, but, as a whole, capable of unusual expansion or development in any direction which early training or the education of life might determine. He also possessed strong passions, which, instead of exerting an unfavorable effect on his character by their indulgence, became, under the restraining influence to which they were in due season subjected, a reserved energy, as it were, ready to manifest itself spontaneously and at any time in the vindication of truth and justice. He was likewise endowed with a power of *will* which, controlling all his faculties and propensities, rendered them subservient to those fixed purposes which had once received the sanction of his deliberate judgment. Eminent also among his characteristics, and perhaps most conspicuous of all, was the social element of refined humanity, a regard for his fellow-man, which craved as an essential want of his nature fraternal sympathy, not only with those within the wide circle of his daily associations, but with those from whom he could expect no reciprocation of the sentiment, the entire brotherhood of mankind. These characteristics, with a nice perception of right and a conscience always ready to enforce its mandates, are, we think, sufficient to explain the remarkable career we have described.

They were perhaps indicated by himself, though with an admission not to be accepted without some reserve, in a conversation with the writer of this sketch in reference to his entrance at West Point. "I knew," he said, "that I had nothing like genius, but I thought I was capable by hard study of accomplishing something, and I resolved to do my best, and if possible to gain the approbation of the teachers, and, above all, to make myself loved and respected by my classmates."

To illustrate the progressive development of the individual traits of his character, we may be allowed to dwell for a moment on a few analytical details. The early period of his life, including that which preceded his first call to Philadelphia, was almost wholly devoted to the improvement of the mechanical, or the "doing" faculties of his mind, and but little attention was given to invention, or the exercise of original thought. His final examination at the Academy, perfect as it was in its kind, only exhibited his capacity for the acquisition of knowledge not the power to originate or apply it. When his efforts were first turned in the latter direction, he evinced, as I well remember, no especial aptitude for it that would indicate future success; but in a short time, and under the stimulus of the associations into which he was thrown in Philadelphia, the faculties of investigation and of generalization were rapidly developed, and had he not been partially turned aside

rom such pursuits, I doubt not but that he would have still more highly listinguished himself in the line of experimental research. Again, the hange in the circumstances and relations of his life produced by his lection to the presidency of Girard College introduced him to a famil- arity with an entirely new class of ideas, which served to exercise and xpand another faculty of his mind, that, namely, which observes and ppreciates moral truths, though without impairing his aptitude for hysical research. In like manner, his foreign mission with reference o popular education, by bringing him into intimate and friendly associa- ion with minds of the first order in the principal cities of Europe, afforded im an opportunity for enlarging the sphere of his sympathies, as well s of studying men under a great variety of social and mental peculiar- ties.

Again, his long residence and high social position at the seat of Gov- rnment, his intimate acquaintance and friendly intercourse with states- nen and politicians, imbued him with a thorough knowledge of the work- ng of the Government, such as few have ever possessed, while his ex- rtions to sustain the Coast Survey and improve its condition served to all into active operation his power to appreciate character, to discern motives, and, therefore, to convince, persuade, and control men. His bility in this latter respect was remarkable; a personal interview with an opponent of the survey scarcely ever failed to convert perhaps an active enemy into an influential friend. His success in this respect often astonished those who frequently harassed Congress with propositions covertly designed to promote their own interest at the expense of public utility; hence the exclamation was not unfrequently heard, "Bache is certainly a wonderful manager." If that which is unusual constitutes, an element of wonder, then the exclamation was not without truth, though not in the sense of those by whom it was uttered, for he never dvocated any measure that was not just, expedient, and proper, either s concerned the interests of the country or the welfare of his species.

On the whole, if we would seek the real secret of his influence over his fellow-men, it would be found, no doubt, to have consisted in the singular abnegation of self which pervaded his whole conduct; his great practical wisdom, his honesty of purpose, and his genial though quiet and unobtrusive manner. In the exercise of these characteristics, he was so far from the least appearance of dissimulation, that no one ever approached him without feeling that it was equally impossible to doubt the purity of his intentions as it was to elude the penetration of his quiet but thorough scrutiny. His calmness served as a shield from within and without; and as a guard against himself as well as a pro- tection against others. It enabled him to weigh the motives and observe the character of those who consulted him with the view of securing his influence or gaining his patronage. His genial nature enabled him to descend gracefully from the heights of science and to enter fully and frankly into the feelings of any company with which he might be

thrown. In this he was aided by a playfulness of fancy and a quiet humor which banished any reserve that might have been produced by a knowledge of his superior talents and attainments. He was, though by no means gifted with those attractions of person which influence at first sight, a favorite with all ages, and particularly with the sex whose discrimination of character is said to be least fallible. It seems almost superfluous to say of such a man that his friendship was open and unwavering, that his confidence once bestowed could be shaken by no mere difference of opinion or conflict of personal interests. Severe to himself under the responsibility of duty, and in the punctual observance of his engagements, his indulgence was reserved for the weak and the erring. Though his outer life was free from disappointments or reverses, and though he walked as it were in perpetual sunshine, all was not so within. Besides the anxiety and solicitude incident to the responsible duties of his position, occasions of trial and profound sorrow were not spared him. He was called to mourn the untimely loss of a beloved brother, who fell a victim to his zeal for the professor's service in the survey of the Gulf Stream; of another brother, the youngest and last, also an officer of the Navy, and a general favorite, who was drowned on the coast of California; and lastly of a sister, whom he had adopted and cherished as a child. In these seasons of affliction he found consolation in the steadfast convictions of religious faith. Nurtured in the forms and principles of the Episcopal church, he was a devout worshiper in the sanctuary, though not bigoted in his attachment to the peculiar ordinances of that communion. He fully recognized the union of science and religion, and held with unwavering constancy the belief that revelation, properly interpreted, and science, rightly understood, must ultimately join in perfect accord in reference to the great truths essential to the well-being of man.

As an evidence of his high appreciation of abstract science derived from original investigation, he left his property in trust to the National Academy of Sciences, the income to be devoted to the prosecution of researches in physical and natural science by assisting experimentalists and observers, and the publication of the results of their investigations.

I here close this imperfect sketch, in which I am conscious of having passed in silence many admirable traits of character and conduct, and of having very inadequately portrayed others, with the remark that, though our companion and brother has departed, his works and his influence still remain to us; that, sorrow as we must for his loss, we can still recall with pride and satisfaction the example he has left us of all that, in heart, in spirit, and in life, the true man of science ought to be.

The following is a list of the published scientific papers of Alexander Dallas Bache, copied from the appendix to an address by Dr. Benjamin

Gould, before the American Association for the Advancement of nce, August 6, 1868.

-Feb. On the specific heat of the atoms of bodies. *Journ. Phila. Acad. Nat. Sci.*, vi, 141.

-May. On the inflammation of phosphorus in a partial vacuum. *Amer. Journ. Sci.*, xviii, 372.

-Mar. Report of the committee of the Franklin Institute, of Pennsylvania, appointed May, 1829, to ascertain by experiment the value of water as a moving power. *Journ. Frank. Inst.*, vii, 145; viii, ix, x, &c.

-April. Safety apparatus for steamboats, being a combination of the fusible metal disk with the common safety-valve. *Journ. Franklin Inst.*, vii, 217; *Amer. Journ. Sci.*, xx, 317.

-Oct. Meteorological observations during the solar eclipse of February 12, 1831. *Trans. Amer. Phil. Soc.*, iv, 132.

-July. Translation of Berzelius's Essay on Chemical Nomenclature. *Amer. Journ. Sci.*, xxii, 248; *Philadelphia*, 1832.

-July. Notice of experiments on electricity developed by magnetism. *Journ. Franklin Inst.*, x, 66; *Amer. Journ. Sci.*, xxii, 409.

-Oct. Alarm to be applied to the interior flues of steam-boilers. *Journ. Franklin Inst.*, x, 217.

-Nov. On the diurnal variation of the magnetic needle. *Trans. Amer. Phil. Soc.*, v, 1.

-Mar. Elementary view of the application of analysis to reflection and refraction. An appendix to Sir David Brewster's treatise on optics. *Philadelphia*, 1833. pp. 95.

-July. Translation of Avogadro's memoir on the elastic force of the vapor of mercury. *Amer. Journ. Sci.*, xxiv, 286.

-July. Note of the effect upon the magnetic needle of the aurora borealis, visible at Philadelphia on the 17th of May, 1833. *Journ. Franklin Inst.*, xii, 5; *Amer. Journ. Sci.*, xxvii, 113.

-Nov. Attempt to fix the date of Dr. Franklin's observation, in relation to the northeast storms of the Atlantic States. *Journ. Franklin Inst.*, xii, 300.

-Dec. Report of experiments on the navigation of the Chesapeake and Delaware Canal by steam. *Journ. Franklin Inst.*, xii, 361.

-Jan. Observations on the disturbance in the direction of the horizontal needle, during the occurrence of the aurora of July 10, 1833. *Journ. Franklin Inst.*, xiii, 1; *Amer. Journ. Sci.*, xxvii, 118.

-Jan. Report of the managers of the Franklin Institute, in relation to weights and measures. Presented in compliance with a resolution of the house of representatives of the State of Pennsylvania. *Journ. Franklin Inst.*, xiv, 6; *Philadelphia*, 1834.

-June. Analysis of some of the coals of Pennsylvania, (made jointly with Professor H. D. Rogers.) *Journ. Phila. Acad. Nat. Sci.*, vii, 158.

-Oct. On the variation of the magnetic needle. *Amer. Journ. Sci.*, xxvii, 385.

-Nov. Observations to determine the magnetic dip at Baltimore, Philadelphia, New York, West Point, Providence, Springfield, and Albany. (made jointly with Professor E. H. Courtenay.) *Trans. Amer. Phil. Soc.*, v, 209.

-Nov. Meteoric observations on and about Nov. 13, 1834. *Amer. Journ. Sci.*, xxvii, 335; *Journ. Franklin Inst.*, xvi, 369.

-Jan. Note relating to the hardening of lime under water, by the action of carbonate of potassa, &c., and to the hardening of carbonate of lime in the air, by potassa and soda. *Journ. Frank. Inst.*, xv, 6.

1835—Mar. Meteorological observations made during the solar eclipse of November 30, 1834. *Trans. Amer. Phil. Soc.*, v, 237.

1835—May. Experimental illustrations of the radiating and absorbing powers of surfaces for heat, of the effects of transparent screens, of the conducting power of solids, &c. *Journ. Franklin Inst.*, xv, 303; *Amer. Journ. Sci.*, xxviii, 320.

1835—May. Replies to a circular in relation to the occurrence of an unusual meteoric display on the 13th of November, addressed by the Secretary of War to the military posts of the United States, with other facts relating to the same question. *Amer. Journ. Sci.*, xxviii, 305; *Journ. Franklin Inst.*, xvi, 149.

1835—June. Experiments on the efficacy of Perkins's steam-boilers or circulators. *Journ. Franklin Inst.*, xv, 379.

1835—July. On the comparative corrosion of iron, copper, zinc, &c., by a saturated solution of common salt. *Journ. Franklin Inst.*, xvi, 2.

1835—Nov. Inquiry in relation to the alleged influence of color on the radiation of non-luminous heat. *Journ. Franklin Inst.*, xvi, 289; *Amer. Journ. Sci.*, xxx, 16.

1835—Dec. Historical notice of a hypothesis to explain the greater quantity of rain which falls on the surface of the ground than above it. *Journ. Franklin Inst.*, xvii, 106.

1836—Jan. Observations upon the facts recently presented by Professor Olmsted in relation to meteors seen on the 13th of November, 1834. *Journ. Franklin Inst.*, xvii, 33; *Amer. Journ. Sci.*, xxix, 383.

1836—Jan. Historical note on the discovery of the non-conducting power of ice. *Journ. Franklin Inst.*, xvii, 182.

1836—Jan. Report of experiments made by the committee of the Franklin Institute of Pennsylvania, on the explosions of steam-boilers, at the request of the Treasury Department of the United States. *Journ. Franklin Inst.*, xvii, 1, 73, 145, 217, 289.

1836—Feb. Remarks on a method, proposed by Dr. Thomson, for determining the proportions of potassa and soda in a mixture of the two alkalies; with the application of a similar investigation to a different method of analysis. *Journ. Franklin Inst.*, xvii, 305.

1836—April. Notes and diagrams illustrative of the directions of the forces acting at and near the surface of the earth, in different parts of the Brunswick tornado of June 19, 1835. *Trans. Amer. Phil. Soc.*, v. 407.

1836—May. Or the relative horizontal intensities of terrestrial magnetism at several places in the United States, with the investigations of corrections for temperature, and comparisons of the methods of oscillation in full and in rarefied air, (jointly with Professor E. H. Courtenay.) *Trans. Amer. Phil. Soc.*, v, 427.

1836—July. Proposed forms of diagrams for exhibiting to the eye the results of a register of the direction of the wind. *Journ. Franklin Inst.*, xviii, 22.

1837—May. Corresponding magnetic observations, in connection with Professor Lloyd of Dublin, to determine the relative magnetic intensity in Philadelphia, Dublin, and Edinburgh. *Proc. R. Irish Acad.*, i, 71.

1838—Aug. Note on the effect of deflected currents of air on the quantity of rain collected by a rain-gauge. *Rep. Brit. Assoc. Adv. Sci.*, 1838, ii, 25.

1839—May. Report on education in Europe, to the trustees of the Girard College for Orphans. 8vo. pp. 666. *Philadelphia*, 1839.

1839—Nov. Comparison of Professor Loomis's observations on magnetic dip with those obtained by Professor Courtenay and himself. *Proc. Amer. Phil. Soc.*, i, 146.

—Nov. Simultaneous magnetic observations, made in correspondence with Professor Lloyd of Dublin. *Proc. R. Irish Acad.*, i, 462; *Amer. Journ. Sci.*, xli, 212.

—Mar. Observations of the magnetic intensity at twenty-one stations in Europe. *Trans. Amer. Phil. Soc.*, vii, 75; *Proc. Amer. Phil. Soc.*, i, 185.

—Nov. Determination of the magnetic dip at Philadelphia and Baltimore. *Proc. Amer. Phil. Soc.*, i, 294.

—Dec. On an instrument for measuring the changes in the vertical component of the force of terrestrial magnetism *Proc. Amer. Phil. Soc.*, i, 311

—May. Diagram of the direction and force of the wind, and amount and rate of rain-fall during the severe gust of April 2, 1841. *Proc. Amer. Phil. Soc.*, ii, 56.

—July. On observations of the magnetic dip, made at Baltimore by Mr. Nicollet and Major Graham. *Proc. Amer. Phil. Soc.*, ii, 83.

—Nov. Account of the formation of cumulus cloud from the action of a fire. *Proc. Amer. Phil. Soc.*, ii, 116.

—Mar. Semi-annual report of the principal of the High School, and report to the controllers of the public schools. *Twenty-fourth Annual Report of Controllers of Public Schools of Philadelphia*, pp. 23, 50.

—April. On the application of the self-registering rain-gauge to registering the fall of snow. *Proc. Amer. Phil. Soc.*, ii, 164.

—July. Report of the principal of the Central High School for the year ending July, 1842. 8vo. pp. 120. *Philadelphia.*

—Oct. Address delivered at the close of the twelfth exhibition of American manufactures, held by the Franklin Institute.

—Dec. On a modification of Lloyd's induction inclinometer. *Proc. Amer. Phil. Soc.*, ii, 237.

—Jan. On a new dew-point hygrometer. *Proc. Amer. Phil. Soc.*, ii, 249.

—May. Results of two years' observations of the magnetic elements, and of the temperature, pressure, and moisture of the atmosphere at the magnetic observatory of Girard College. *Proc. Amer. Phil. Soc.*, iii, 90.

—May. Account of an instrument for determining the conducting power of bodies for heat. *Proc. Amer. Phil. Soc.*, iii, 132.

—May. Account of observations at Philadelphia and Toronto, during the magnetic disturbance of May 6, 1843, and their bearing upon the question of the kind of instruments and observations appropriate to determine such phenomena. *Proc. Amer. Phil. Soc.*, iii, 175.

—Feb. Report to the Treasury Department on the progress of construction of standard weights and measures. *Senate Doc.* 149, *28th Congress, 2d Session.*

—Dec. Description of a new base apparatus used in the United States Coast Survey. *Proc. Amer. Phil. Soc.*, iv, 368.

—Dec. On a new method of observing transits. *Monthly Not. R. Astr. Soc.*, ix, 123; *Bull. Acad. Sci., Brussels*, xvi, 313; *Astr. Nachr.*, xxviii, 273.

—Aug. Comparison of the results obtained in geodesy by the application of the theory of least squares. *Proc. Amer. Assoc. Adv. Sci., Cambridge*, 1849, p. 102.

—Aug. On the progress of the survey of the coast of the United States. *Proc. Amer. Assoc., Cambridge*, 1849, p. 162.

—Mar. Notes on the results of observations of the direction and force of the wind at the Coast Survey stations at Mobile Point and at Cat Island, Gulf of Mexico. *Proc. Amer. Assoc., Charleston*, 1850, p. 50.

—Mar. Abstract of a communication on the recent progress of the telegraphic operations of the United States Coast Survey. *Proc. Amer. Assoc., Charleston*, 1850, p. 122.

1850—Aug. Method used in the Coast Survey for showing the results of current observations. *Proc. Amer. Assoc., New Haven*, 1850, p. 70; *C. S. Rep.*, 1850, p. 136.

1850—Aug. Remarks upon the meeting of the American Association at Charleston, in March, 1850. *Proc. Amer. Assoc., New Haven*, 1850, p. 159.

1850—Aug. Notes of a discussion of tidal observations, in connection with the Coast Survey, made at Cat Island, in the Gulf of Mexico. *Proc. Amer. Assoc. New Haven*, 1850, p. 281; *Amer. Journ. Sci.*, xii, 341; *C. S. Rep.*, 1851 p. 127.

1851—May. Current chart of New York Bay, from observations in the Coast Survey. *Proc. Amer. Assoc., Cincinnati*, 1851, p. 43.

1851—May. Comparison of curves showing the hourly changes of magnetic declination at Philadelphia, Toronto, and Hobarton from April to August, and from October to February, and for March and September. *Proc. Amer. Assoc., Cincinnati*, 1851, p. 62.

1851—May. On the determination of the velocity of sound by the method of coincidences. *Proc. Amer. Assoc., Cincinnati*, 1851, p. 75.

1851—May. Notes on the use of the zenith telescope in determining latitudes in the Coast Survey by Talcott's method, and on the reduction of the observations. *Proc. Amer. Assoc., Cincinnati*, 1851, p. 151; *Amer. Journ. Sci.*, xiv, 191.

1851—Aug. Additional notes of a discussion of tidal observations made in connection with the Coast Survey at Cat Island, Louisiana. *Proc. Amer. Assoc., Albany*, 1851, p. 94; *Amer. Journ. Sci.*, xiv, 346; *C. S. Rep.*, 1852, p. 111.

1851—Aug. Notes on the tides at Sand Key, near Key West, Florida. *Proc. Amer. Assoc., Albany*, 1851, p. 138.

1851—Aug. Address on retiring from the duties of president of the American Association for the Advancement of Science. *Proc. Amer. Assoc., Albany*, 1851, p. 41.

1852—Mar. Report on the harbor of Charleston, South Carolina, (as chairman of a committee.)

1853—July. On the tides at Key West, Florida, from observations made in connection with the United States Coast Survey. *Proc. Amer. Assoc., Cleveland*, 1853, p. 32; *Amer. Journ. Sci.*, xviii, 395; *C. S. Rep.*, 1853, p. 71.

1853—July. On the tides of the western coast of the United States, from observations at San Francisco, California, in connection with the United States Coast Survey. *Proc. Amer. Assoc., Cleveland*, 1853, p. 42; *Amer. Journ. Sci.*, xxi, 1; *C. S. Rep.*, 1853, p. 77.

1854—May. Preliminary determination of co-tidal lines on the Atlantic coast of the United States, from the Coast Survey tidal observations. *Proc. Amer. Assoc., Washington*, 1854, p. 107; *Amer. Journ. Sci.*, xxi, 14; *C. S. Rep.*, 1854, p. 147.

1854—May. Comparison of the diurnal inequality of the tides at San Diego, San Francisco, and Astoria, on the Pacific coast of the United States, from observations in connection with the Coast Survey. *Proc. Amer. Assoc., Washington*, 1854, p. 161; *Amer. Journ. Sci.*, xxi, 10; *C. S. Rep.*, 1854, p. 152.

1854—May. On the distribution of temperature in and near the Gulf Stream, off the coast of the United States, from observations made in the Coast Survey. *Proc. Amer. Assoc., Washington*, 1854, p. 134; *Amer. Journ. Sci.*, xxi, 29; *C. S. Rep.*, 1854, p. 156.

1854—June. Second report on the harbor of Charleston, South Carolina.

1855—Feb. Discussion of observations for the isodynamic, isogonic, and isoclinal curves of terrestrial magnetism, on and near the line of the boundary survey between the United States and Mexico, made in 1849–1852,

under the order of W. H. Emory, and combined with observations at San Francisco, California, and Dollar Point, (E. Base,) and Jupiter, Texas. *Mem. Amer. Acad. Arts and Sci.*, v, 372.

5—Aug. Approximate co-tidal lines of the Pacific coast of the United States, from observations in the United States Coast Survey. *Proc. Amer. Assoc., Providence*, 1855, p. 144; *C. S. Rep.*, 1855, p. 338.

5—Aug. Notice of the tidal observations made on the coast of the United States, on the Gulf of Mexico, with type-curves at the several stations, and their decomposition into the curves of diurnal and semi-diurnal tides. *Proc. Amer. Assoc., Providence*, 1855, p. 152; *Amer. Journ. Sci.*, xxi, 128; *C. S. Rep.*, 1855, p. 346.

5—Aug. Notice of earthquake waves on the western coast of the United States on the 23d and 25th of December, 1854. *Proc. Amer. Assoc., Providence*, 1855, p. 153; *Amer. Journ. Sci.*, xxi, 37; *C. S. Rep.*, 1855, p. 342.

5—Dec. Report to New York harbor commissioners, on surveys of New York Harbor.

5—Jan. Annual address before the American Geographical Society, being a paper upon the Gulf Stream. *Bulletin Amer. Geogr. Soc.*, ii, 94.

5—Aug. Approximate co-tidal lines of diurnal and semi-diurnal tides of the coast of the United States on the Gulf of Mexico. *Proc. Amer. Assoc., Albany*, 1856, p. 168; *Amer. Journ. Sci.*, xxiii, 12; *C. S. Rep.*, 1856, p. 252.

6—Aug. On the general distribution of terrestrial magnetism in the United States, from observations made in the United States Coast Survey and others, (in connection with Mr. J. E. Hilgard.) *Proc. Amer. Assoc., Albany*, 1856, p. 187; *Amer. Journ. Sci.*, xxvi, 1; *C. S. Rep.*, 1856, p. 209.

6—Aug. Observations to determine the cause of the increase of Sandy Hook, made by the Coast Survey for the commissioners on harbor encroachments. *Proc. Amer. Assoc., Albany*, 1856, p. 171; *Amer. Journ. Sci.*, xxiii, 16; *C. S. Rep.*, 1856, p. 263.

6—Aug. Notice of observations to determine the progress of the tidal wave of the Hudson River, made by the Coast Survey for the commissioners on harbor encroachments. *Proc. Amer. Assoc., Albany*, 173; *Amer. Journ. Sci.*, xxiii, 17.

6—Aug. Notes on the progress made in the Coast Survey in prediction-tables for the tides of the United States coast. *Proc. Amer. Assoc., Albany*, 1856, p. 166; *C. S. Rep.*, 1856, p. 249.

6—Oct. Anniversary address before the American Institute of the city of New York, during the twenty-eighth annual fair. *New York*, 1857, pp. 60.

6—Dec. Report to New York harbor commissioners on the progress of the survey of New York harbor.

6—Dec. Notes on the winds of the coast of the United States on the Gulf of Mexico. *C. S. Rep.*, p. 272.

6—Dec. Report of Superintendent of Weights and Measures.

7—Aug. Notice of the determination of the longitude of Fernandina, Amelia Island, Florida, by means of chronometer exchanges from Savannah, Georgia, (in connection with Mr. C. A. Schott.) *Proc. Amer. Assoc., Montreal*, 1857, p. 166; *C. S. Rep.* 1857, p. 314.

7—Aug. On the heights of the tides of the Atlantic coast of the United States, from observations in the Coast Survey. *Proc. Amer. Assoc., Montreal*, 1857, p. 175; *Amer. Journ. Sci.*, xxv, 47; *C. S. Rep.*, p. 342.

7—Aug. On the winds of the western coast of the United States, from observations in connection with the United States Coast Survey. *Proc. Amer. Assoc., Montreal*, 1857, p. 183; *Amer. Journ. Sci.*, xxv, 52; *C. S. Rep.*, 1857, p. 354.

1857—Aug. Notes on the measurement of the base of the primary triangulation of the eastern section of the coast of the United States, on Epping Plains, Maine. *Proc. Amer. Assoc., Montreal*, 1857, p. 160; *Amer. Journ. Sci.*, xxv, p. 58; *C. S. Rep.*, 1857, p. 302.

1857—Dec. Report relative to the New York harbor survey. *U. S. Senate Doc.*, 1858, No. 16.

1858—May. On a supposed personal equation in the use of the zenith telescope, for determining latitudes by Talcott's method. *Proc. Amer. Assoc., Baltimore*, 1858, p. 14; *C. S. Rep.*, 1858, p. 184.

1858—May. On the tidal currents of New York Bay, near Sandy Hook. *Proc. Amer. Assoc., Baltimore*, 1858, p. 80; *Amer. Journ. Sci.*, xxvi, 334; *C. S. Rep.* 1858, p. 197.

1858—July. Defense of Dr. Gould, by the scientific council of the Dudley Observatory, (in connection with Professors Joseph Henry and Benj. Peirce.) *Albany*, 1858, pp. 91.

1859—Feb. Address before the Alumni Association of the Central High School. *Philadelphia*, 1859.

1859—June. Address in tribute to the memory of Humboldt. *The Pulpit and Rostrum*, No. 6.

1859—Aug. General account of the results of the discussion of the declinometer observations, made at Girard College, Philadelphia, between the years 1840 to 1845, with special reference to the eleven-year period. *Proc. Amer. Assoc., Springfield*, 1859, p. 248.

1859—Aug. Gulf-Stream explorations. Third memoir. Distribution of temperature in the water of the Florida Channel and Straits. *Proc. Amer. Assoc., Springfield*, 1859, p. 257; *Amer. Journ. Sci.*, xxix, 199; *C. S. Rep.*, 1859, p. 306.

1859—Nov. Discussion of the magnetic and meteorological observations made at the Girard College observatory, Philadelphia, in 1840 to 1845, Part I. Investigation of the eleven-year period in amplitude of the solar diurnal variation, and of the disturbances of the magnetic declination. pp. 22. *Smiths. Contrib. to Knowledge*, vol. xi, art. iv; *C. S. Rep.*, 1859, p. 278.

1860—Aug. Lecture on the Gulf Stream. *Proc. Amer. Assoc., Newport*, 1860, p. xlix; *Amer. Journ. Sci.*, xxx, 313; *C. S. Rep.*, 1860, p. 165.

1860—Aug. General account of the results of Part II of the discussion of the declinometer observations made at the Girard College, Philadelphia, between 1840 and 1845, with special reference to the solar diurnal variation and its annual inequality. *Proc. Amer. Assoc., Newport*, 1860, p. 74; *Amer. Journ. Sci.*, xxxi, 197.

1860—Aug. Abstract of a discussion of the influence of the moon on the declination of the magnetic needle, from the observations at the Girard College. *Proc. Amer. Assoc., Newport*, 1860, p. 83; *Amer. Journ. Sci.*, xxxi, 98.

1860—Sept. Observations of the solar eclipse of 1860, July 18, at the Coast Survey station, Gunstock Mountain. *Astron. Journ.*, vi, 157.

1862—June. Discussion of the magnetic and meteorological observations made at the Girard College observatory, Philadelphia, in 1840 to 1845, Part II. Investigation of the solar diurnal variation of the magnetic declination and its annual inequality, pp. 28. *Smiths. Contrib. to Knowl.*, vol. xiii, art. v; *C. S. Rep.*, 1860, p. 293.

1862—June. Discussion of the magnetic and meteorological observations made at the Girard College observatory, Philadelphia, in 1840 to 1845, Part III. Investigation of the influence of the moon on the magnetic declination, pp. 16. *Smiths. Contrib. to Knowl.*, vol. xiii, art. vi; *C. S. Rep.*, 1860, p. 312.

1862—Sept. Abstract of a discussion of the horizontal component of the magnetic

force, from observations made at the Girard College observatory, Philadelphia, in the years 1840 to 1845. *Amer. Journ. Sci.*, xxxiv, 261.

—Nov. Discussion of the magnetic and meteorological observations made at the Girard College observatory, Philadelphia, in 1840 to 1845, second section, comprising Parts IV, V, VI. Horizontal force, investigation of the ten or eleven year period, and of the disturbances of the horizontal component of the magnetic force; investigations of the solar diurnal variation and of the annual inequality of the horizontal force, and the lunar effect on the same, pp. 78. *Smiths. Contrib. to Knowl.*, vol. xiii, art. viii; *C. S. Rep.*, 1862, p. 161.

—Nov. Abstract of an investigation of the solar diurnal variation of the annual inequality of the horizontal component of the magnetic force, from observations made at the Girard College observatory, between 1840 and 1845. *Amer. Journ. Sci.*, xxxiv, 373.

—Nov. Abstract of a discussion of the influence of the moon on the horizontal magnetic force, from observations made at the Girard College observatory, in the years 1840 to 1845. *Amer. Journ. Sci.*, xxxiv, 381.

—Dec. Additional researches on the co-tidal lines of the Gulf of Mexico. *C. S. Rep.*, 1862, p. 126.

—Jan. Eulogy on Hon. James Alfred Pearce. *Annual Report of Regents Smithsonian Institution for* 1862, p. 100.

—May. Abstract of results of a magnetic survey of Pennsylvania and parts of adjacent States in 1840 and 1841, with some additional results of 1843 and 1862, and a map. *Amer. Journ. Sci.*, xxxv, 359; *C. S. Rep.*, 1862, p. 212.

—Oct. Records and results of a magnetic survey of Pennsylvania and parts of adjacent States in 1840 and 1841, with some additional records and results of 1834, 1835, 1843, and 1862, and a map, pp. 88. *Smiths. Contrib. to Knowl.*, vol. xiii, art. viii.

—May. Discussion of the magnetic and meteorological observations made at the Girard College observatory, Philadelphia, in 1840 to 1845, third section, comprising Parts VII, VIII, IX. Vertical force. Investigation of the eleven (or ten) year period, and of the disturbances of the vertical component of the magnetic force, and appendix on the magnetic effect of the aurora borealis; with an investigation of the solar diurnal variation, and of the annual inequality of the vertical force, and of the lunar effect on the vertical force, the inclination and total force, pp. 72. *Smiths. Contrib. to Knowl.*, vol. xiv, art. ii; *C. S. Rep.*, 1863, p. 156.

—Jan. Discussion of the magnetic and meteorological observations made at the Girard College observatory, Philadelphia, in 1840 to 1845; fourth section, comprising Parts X, XI, XII. Dip and total force. Analysis of the disturbances of the dip and total force; discussion of the solar diurnal variation and annual inequality of the dip and total force; and discussion of the absolute dip, with the final values for declination, dip, and force, between 1841 and 1845, pp. 44. *Smiths. Contrib. to Knowl.*, vol. xiv, art. iii; *C. S. Rep.*, 1864, p. 183.

to 1863. Annual reports of the progress of the United States Coast Survey.

to 1848. Annual reports of Superintendent of Weights and Measures.

to 1863. Tide tables for the use of navigators, prepared from the Coast Survey observations, annually.

Also, the following reports concerning harbors, jointly with Messrs. Eaton and Davis:

—Mar. Report upon Cape Fear River and harbor.

—Oct. *Report of Portland harbor* commission.

1855—Mar. Second report of the commissioners on Portland harbor.

1855—Dec. Report of advisory council of the New York harbor commission. *New York Assembly Doc.*, 1856, No. 8.

1856—July. Report of the advisory council of the New York harbor commission, recommending certain lines in the East and North Rivers, and in Brooklyn. *New York Senate Doc.*, 1857, No. 40, p. 107.

1856—July. Report of the advisory council of the New York harbor commission on Gowanus Bay and its improvements. *New York Senate Doc.*, 1857, No. 40, p. 118.

1856—Sept. Report of the advisory council of the New York harbor commission on the Hell Gate Passage, regarded as a channel of approach to New York harbor. *New York Senate Doc.*, 1857, No. 40, p. 137.

1856—Oct. Second general report of the advisory council to the harbor commissioners, on lines in New York harbor. *New York Senate Doc.*, 1857, No. 40, p. 81.

1856—Dec. Report of the advisory council to the commissioners on harbor encroachments of New York, in regard to safe and commodious anchorages in New York harbor, for the purposes of the quarantine of vessels. *New York Senate Doc.*, 1857, No. 40, p. 132.

1856—Dec. Report of the advisory council to the New York harbor commissioners upon Harlem River and Spuyten Duyvil Creek. *New York Senate Doc.*, 1857, No. 40, p. 151.

1857—Feb. Report of the advisory council of lines for the East River, for the shore of Long Island, and the east shore of Staten Island. *New York Senate Doc.*, 1857, No. 126, p. 9.

1857—Mar. Report of the advisory council to the New York harbor commissioners upon the comparative map of New York Bay and harbor, and its approaches, prepared by the Coast Survey in March, 1857. *New York Senate Doc.*, 1857, No. 126, p. 12.

1860—Mar. Preliminary reports of commissioners on Boston harbor. *Boston City Doc.*, 1860, No. 37.

1860—Dec. Second report of United States commissioners on the condition of Boston harbor. *Boston City Doc.*, 1860, No. 97.

1860—Dec. Special report of the United States commissioners on Boston harbor, on the relation of Mystic Pond and River to Boston harbor. *Boston City Doc.*, 1861, No. 12.

1860—Dec. Report of the advisory council of the joint committee of the Massachusetts legislature on the subject of a ship-canal to connect Barnstable Bay and Buzzard's Bay. *Mass. Pub. Doc.*, 1864, No. 41.

1861—Sept. Fourth report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1861, No. 62.

1861—Sept. Fifth report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1861, No. 63.

1863—April. Sixth report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1863, No. 53.

1864—Mar. Seventh report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1864, No. 33.

1864—Mar. Eighth report of the United States commissioners on Boston harbor. *Boston City Doc.*, 1864, No. 34.

LECTURE ON SWITZERLAND.

By Alexander Dallas Bache.

e following lecture on Switzerland, from the manuscript of Professor Bache, is ublished for the first time to illustrate in connection with the foregoing eulogy bit of observation and his facility of description. It presents, however, a lively ı of one of the most interesting portions of the earth, whether considered from a ical or physical point of view, and we doubt not will be read with pleasure, ally by all who have been favored with a visit to the delightful region which it bes. The original notes from which the lecture was prepared were taken during ofessor's visit to Switzerland in 1837-'38. The foot-notes, exhibiting the present ion of the country, have been kindly furnished to us by the Hon. Mr. Hitz, Swiss general in this city.—J. H.]

ıvelers relate that in certain conditions of the atmosphere a spec- standing upon the shore at Reggio, and looking upon the smooth rs of the Straits of Messina, sees suddenly rise before him, as if by c, the walls, towers, palaces, domes, and streets of a city, in which c life goes on, men and animals moving noiselessly to and fro. The on is as complete as if the waters of the bay were a foundation which the genii of the lamp or of the ring had suddenly erected magic structures. This is an extreme case of the ordinary illusion ınted to those who, in a calm clear day, look at distant objects ıs a wide expanse of bay or river. Familiar forms are strangely rted; level shores appear precipitous; the puny sloop swells into ize of a frigate; the fisherman's boat becomes a dismasted sloop, ts occupant a giant. Just so it is when in mental vision we attempt ɔk through an atmosphere disturbed by the habits and prejudices hich we are accustomed. Unreal towers and walls appear, and ts so lose their shapes that the most familiar forms escape recog- ı. Every country has its prejudices resulting from education, from ıe influences, political, moral, social, and physical which surround ıct upon its citizens. By these, in general, the observer of men things is biased, and he who through the mists of *his* national or ɔnal prejudices seeks to realize their just forms and proportions, mistake the pigmy for a giant, the shallop for a frigate.

estimating the institutions of the Old World we are prone to forget the materials for our judgment are generally furnished by the opin- of those who are brought up under a totally different state of things that which exists around us. The conclusions which we thus form be the very opposite of those to which we would have come our- ·s, had our own prepossessions furnished the inferences from the . In neither case, perhaps, would truth be arrived at, but in the

former the result may be deeply injurious, because leading to modes and habits of thought and action not in harmony with the peculiarities of our country.

Impressed with the importance to Americans of judging independently of the institutions of Europe, I formerly took occasion in another place to present a cursory view of the capital of Austria, as illustrating the effects of institutions the very opposite of our own. I design on this occasion to occupy your attention, without further exceeding the limits of a lecture than is absolutely necessary, by a notice of men and things in the only federated republic of Europe, Switzerland. I cannot pretend to set before you a panoramic view, but merely a few detached pictures in outline, so selected as to convey a tolerably fair idea of republican Switzerland as it appeared to an American. By contemplating it we shall have an example of the practical working of republicanism in the Old World, under various modifications, and with the disadvantages of being hemmed in on all sides by monarchies. We shall thus see the power of this system to civilize and to enlighten.

In the course of these sketches we shall find much bearing both directly and indirectly upon the objects which this Institute was established to promote. Upon the map of Europe Switzerland is so well defined by its boundaries that there is no danger of its escaping the sight on account of its small size. The Rhine constitutes nearly two sides of this boundary, from the point where the various streams from the glaciers of the Grisons have met to form a river into the lake of Constance, and from its exit thence to where the Jura Mountains turn its course to the Northern Ocean. The Jura separates Switzerland from France, and with merely an outlet for the Rhone, the Alps take up the line, dividing rugged Switzerland from the plains of Northern Italy.

The picturesque features of this country have furnished themes for the poet, the painter, and tourist. Under the influence of its snow-capped mountains, its shady and sequestered valleys, its rough glaciers, and its placid lakes, common-place men have warmed into something approaching to poetic fervor, and men of genius have poured forth their inspirations in verse or lofty prose. It is impossible to call up even in memory those scenes with all their attendant circumstances of romance—both nature and life so different from that to which we are accustomed—without feeling the heart and the imagination moved beyond their wont.

> "Who first beholds those everlasting clouds—
> Those mighty hills, so shadowy, so sublime,
> As rather to belong to heaven than earth,
> But instantly receives into his soul
> A sense, a feeling, that he loses not;
> A something, that informs him 'tis an hour
> Whence he may date henceforward and forever."

But who shall dare to speak in plain prose of scenes of which the muse of Byron has sung? The rugged nature of the country within this bound-

ary has had its effect in determining the character of institutions as well as of individuals. Small tracts of country are as completely separated by mountains of difficult passage, as by distance, differ in the modes and facilities of life, have different interests, and consequently separate organizations. The character of the topography has divided the country into many small states, and has produced striking differences in language and manners, in religions, social and political organization, in a country of not more than one-third the extent of Pennsylvania, and with about the same population of that entire State.

The present Swiss confederation consists of twenty-two sovereign states called cantons, the division of which, according to geographical position, includes also that of language.* Thus the north and middle of Switzerland contains the sixteen cantons where a dialect of the German is spoken, Zurich being the principal canton on the north, and Berne in the middle. To the west and south of the middle are the mixed German and French cantons of Neuchâtel, Friberg, and Valais; to the southeast the mixed German Romanic and Italian canton of the Grisons, or gray league, subdivided into its little sovereign states. On the southwest are the French cantons of Vaud and Geneva, and on the south of the middle the Italian canton of Tessin. While the language spoken by these people is determined by their proximity to those who speak it in its purity, their social, religious, and political institutions may almost be said to be uninfluenced by this circumstance. These are the results of other causes, many of which may be found in their history.

A Florentine scholar relating to me unpublished anecdotes of the horrors enacted by members of the far-famed family of the Medici, with Italian fervor broke out into this apostrophe: "Happy your great country, which has not the chains of a dark history to bind it to the institutions and manners of a by-gone age. Beware how you men of the present day sully the pure page which records the actions of your forefathers, of your Adams, your Franklin, your Washington."

The condition of a country at a past day must assuredly influence its present state as the summer's sun upon the snow-covered mountains of the Alps increases the autumnal flow of the river whose sources lie among them, or as the accumulation of the winter's snow upon the mountain's peak produces the summer's avalanche.

The history of the Swiss republics shows the circumstances which prepared and the impulses which gave existence to each, and a glorious history it is upon which to found progress in virtue and liberty.

Nearly in the center of Switzerland is a mountainous district which the Romans never reached, into which the bands of Attila never penetrated, and where no ruins of feudal castles exist to show that in the

*To wit: Zurich, Berne, Lucerne, Uri Schwyz, Unterwalden, (upper and lower,) Glarus, Zug, Friburg, Solerne, Basil, (city and country,) Schaffhausen, Appenzel, (both Rhodes,) St. Gallen, Grisons, Aargan, Thurgan, Tessin, Vaud, Valais, Neuchatel, and Geneva.

Middle Ages the inhabitants had a master. Divided, generally, by rocky barriers into separate communities, the people are in a degree united by the beautiful lake of the Forest cantons. These people, from the earliest records, have been, and are now, poor and pastoral. They form the democratic cantons of Schwyz, Uri, and Unterwalden, the nucleus of Swiss confederation. As early as the twelfth century they had a representative at the court of the Emperor of Germany, then the titular sovereign of Switzerland. Rudolph of Habsburg, whose castle was near the confluence of the Reuss and the Aar, the father of the founder of the house of Austria, was elected the representative of these peasants, and subsequently the family claimed the dignitary to be hereditary. This claim was never admitted, and to its impolitic enforcement by Albert of Habsburg, accompanied by circumstances of peculiar indignity on his own part, and of great cruelty and oppression on the part of his bailiff Gessler, was owing the revolution headed by Tell and his companions.

In pursuit of these same hereditary rights, Frederick of Austria, with his armies, entered the Forest cantons by their mountain passes, determined to overrun and crush them. He was successfully resisted at the pass of Morgarten by one thousand three hundred men, and nine thousand of his troops perished in this defeat. Thus was developed that fierce military spirit which has led the Swiss of every age to acts of the most devoted heroism.

From their wars with the dukes of Austria, the Swiss came out in 1412 with eight cantons recognized as independent. The appetite for war had been whetted by this successful resistance to oppression, and was carried to its height by the defeat of Charles the Bold of Burgundy, and of his magnificent troops, at Grandson and at Morat. The spoils of these great armies suddenly enriched the people. Labor was neglected and fell into contempt, and the profession of arms alone considered worthy occupation for a Swiss. The nation was for a time debased by a mercenary military spirit, and it required two centuries of bloodshed to impress the lessons necessary to their regeneration. The wars of the Reformation gave the last of this series of unhappy lessons, and at their close left the several cantons confirmed in their attachment to the same churches in behalf of which they had expended to no purpose their blood and treasure. In 1712 the confederation had attained nearly its present limits, but some of the present cantons were held as tributary provinces by the others. The Swiss spirit of former days burst forth when republican France began to proselyte by force of arms, and the constitution of the new Helvetic republic was presented at the point of the sword, and enforced by its edge. While the cantons of the plain were held by the French armies, pleasantly occupied in appropriating the savings of the aristocrats, and in giving liberty to the people by depriving them of their independence, the Forest cantons dared to declare that they had been free since the days of Tell, and Melchthal,

and Winkelried; that they required no lessons in self-government, and would resist invasion of their civil and religious rights to the death. Aloys Reding, a descendant of Rudolph, who had defeated Frederick of Austria at the pass of Morgarten five hundred years before, occupied again that Thermopylæ of his country. The mode of warfare had changed; personal strength has little advantage in contests with fire-arms; rocks and stones, though launched from mountain heights, are imperfect substitutes for cannon balls; numbers can no longer be counterbalanced by valor. Four thousand men, aided by their women and children, held this pass two days against forty thousand, but at last were forced to yield, and the Forest cantons received the constitution which they could no longer resist.

The days of the Jacobins passed; those of the First Consul and Emperor dawned, waxed, and waned, and Switzerland was the battle-ground on which the French, Austrians, and Russians contended, everywhere desolating the country with fire and sword. The pacification of Europe put an end to the horrible scenes then enacted, and the republics of Switzerland were left to reorganize themselves, affording in their rapid recovery from their desolate condition a strong evidence of the energy of the people. The organization then adopted, with some changes, exists at present. Forty years of exemption from war have obliterated the external marks of the misery of the country, but in the institutions of the different States the influence of their past history is still entirely visible.

The rough sketches which I must pass rapidly before you, to give some idea of the present condition of the country, will be taken from the French and German cantons—those which exercise the most influence upon Switzerland as it is, and as it will be.

Geneva, the oldest city of the confederation, is the frontier town upon the southwest. Its foundation dates before that of Rome itself. The inhabitants were among those Helvetians whom the fortune of war at last put at the mercy of the Romans who occupied the city with their legions. The Middle Ages found it a place of importance under the sovereignty of the Duke of Savoy; the see of a bishop, nominated by the duke, who was the temporal as well as the ecclesiastical ruler. History represents its moral and intellectual condition to have been low, its commerce moderate. Under the preaching of Farel in 1535 the citizens declared for the Reformation, and drove the bishop from their walls. In 1536, Calvin, a native of Picardy, came among them, and by his powerful preaching brought about a second reformation which changed entirely not only the face of society, but the habits and modes of thought and action of the people.

At a little distance from the water the shores of Lake Leman, or the Lake of Geneva, rise abruptly, and on this irregular ground, just where the Rhone issues from the lake, the city is built. The nature of the site thus divides Geneva into an upper and lower town. Below, and on the

steep streets occupying the slope, are the houses and shops of the tradesmen, and on the hill are those of the more wealthy citizens, once the Genevese aristocracy. The suburb on the opposite bank of the Rhone is joined by bridges to the old town, and rivals the hill-top, by its fine houses. The town is surrounded by ramparts, once of use to resist enemies and now affording pleasant promenades. These ramparts often protected the town in times gone by, but did not prevent its occupation by the French in 1798, and must necessarily yield to any enemy which has the means of bombarding the city. The conviction of their inutility has led the liberal governments of Berne and Zurich to raze these ramparts to the ground.*

The anniversary of an unsuccessful attempt, by the Savoyards, in 1602, to surprise the city, is still celebrated. Under cover of a dark night, and by the use of scaling ladders painted black the better to conceal them, a party of the enemy's pioneers had mounted the walls and penetrated into the town, when they were discovered by the careless watch. The citizens were surprised but not daunted, and issuing from their houses with such arms as they could seize, fell upon the invaders. The first gun fired from the ramparts carried away several of the scaling ladders, and prevented succor. In the morning the people assembled in the venerable church of St. Peter, when the pastor opened public worship by giving out the 124th Psalm; and since, on every 12th of December, the same sounds arise from the voices of many worshipers:

"If it had not been the Lord who was on our side, now may Israel say:
"If it had not been the Lord who was on our side when men rose up against us."

The University of Geneva was founded by Calvin, in 1564, and has always enjoyed a high reputation. In order to connect it advantageously with the grammar schools which prepare its pupils, the auditories have been provided, in which the character of the studies, the modes of teaching, and the discipline are intermediate between those of the school and of the university. Public instruction is under the control of the council of state, but while the impress of the best minds in this intellectual city is upon its higher institutions, the common schools are not, nor can they soon be made, what they ought to be. Like most of their fellow-republicans of the United States, the Genevese began their educational edifice at the top. They have yet to learn that parsimony in education under a popular government is waste; that unless instruction be really public it is better left entirely in the hands of individuals; that it is in vain to move the waters and then to pretend to say to the raised wave, thus far shalt thou go and no farther. The Genevese youth of families in easy circumstances find means of the best education: do they on this account effectively control those to whom the so-called republic gives less light? Witness the frequent revolutions in this city, and these not always without bloodshed. The government is founded

* The ramparts here referred to have all been removed, and Geneva at the present date (1871) presents no evidences of ever having been a fortified city.

a popular revolution, and all attempts to impede the progress of pop-
r institutions must in the end prove futile. If the light of education
denied to the people by their rulers, the revolutions will be bloody;
in no case can there be happiness or safety without the full exercise
opular rights, by a thoroughly educated people.*

alvin, as head of the consistory, whose members then formed one-
d of the council of state, governed Geneva, and impressed his own
ere character upon the laws and manners. Public amusements
e prohibited and private regulated. The number of guests to be
ted to weddings of the first, second, and third class, was made the
ject of municipal regulation. All dancing was interdicted, and
n it was found that if the violin were played people would dance,
use of the instrument was prohibited. The absence of light amuse-
nts, together with religious feeling, naturally led to a greater use of
se relaxations deemed lawful, and to the more active pursuit of science
literature by the better educated. Though times have changed in
neva, in regard to religious creed as well as to amusements, the im-
ss of former days is still strong upon it, and those who term it "a
le Paris" do not look beneath the surface.

There is a curious mixture of the traits, manners, and modes of life
both France and England in this city, with a basis which is entirely
nevese. No less than ten thousand strangers, including, however,
iss of other cantons, reside permanently in a town of thirty thousand
abitants, and the number passing through it in a year is reckoned to
as great as the population itself. The influence of their manners is,
course, considerable, notwithstanding the exclusiveness of Genevese
iety. This exclusiveness is fostered among the ladies in the usual
y, and among the men by clubs, literary, scientific, for conversation
l mere amusement. It even begins among the children, who associ-
in little knots called Sunday societies, the members of which keep
with each other the intercourse of cousins. Many Genevese enter
o commercial life abroad, and after accumulating wealth return to
ir home, few (except those who have migrated to the United States)
coming identified with foreign countries.

The most prominent business in Geneva is the manufacture of jewelry,
d of watches. Each part of the watch is the special occupation of
e class of workmen. Different portions of the works are made by
asants, but the finishing and putting together of the whole, as
ll as the manufacture of the cases, employ the artisans of Geneva.
arly three thousand persons within the town, about one-fifth of
e men, are occupied in the jewelers' and watch-makers' business,
d twenty thousand watches are made annually. † The restrictive

* The school system of Geneva has undergone a material change, and public schools
all grades are liberally provided for.

† The census of 1870 show seven thousand persons engaged in watch-making, and
ward of 200,000 watches made per annum.

duties laid upon these manufactures by neighboring countries, and especially by France, have led to a regularly organized system of smuggling, from which the government agents appear to derive a private revenue, and which is, therefore, very difficult to break up. It is said that a prefect of police of Paris, having bought at Geneva jewelry and watches to a considerable amount, the tradesman offered to deliver them in Paris for an additional sum much below the cost of carriage and the duties. The prefect made the agreement, and gave notice at the frontier custom-houses, describing the articles, and requiring even more than usual vigilance. The articles were, nevertheless, delivered to him according to contract, and on investigation he found that they had passed the frontier in his own baggage. This is one of the devious ways of trade which is, I fear, not peculiar to any nation, and which the better moral tone to be cultivated by associations like that which I now address may and should correct. To elevate the watchmakers' art, a society has been formed for the preliminary education of apprentices, and prizes for attainments in mathematics, drawing, and kindred subjects, are awarded to successful competitors.

The political changes in Geneva have been of an instructive kind. The people declared for the Reformation, and threw off the authority of the Duke of Savoy. Thus the popular will was the basis of the existence of the present government. The necessity for constant resistance to enemies without produced an easy concentration of power in the hands of a few, and by limiting the number of families from among the members of which the rulers were chosen, the government was rendered practically an aristocracy, not of rank, for the *patricians* of Geneva have always refused even this title, but of wealth and intelligence. The warfare of practice against principle has caused many revolutions, all leading to an extension of popular privileges, and though likened by the Emperor Paul, of Russia, to storms in a tumbler, their influences, direct and indirect, have spread widely. Between the year 1535, when the Bishop of Geneva was violently expelled from the city, and the year 1837, there had been five revolutions, and including two unsuccessful but violent popular commotions, and seven attempts to alter the government. And thus it must be until the end of the chapter, until privileges and rights are in harmony—until, in other words, Geneva is a true republic.

The chief points of dispute still are (unless recent events have settled some of them) that the sovereignty of the people is not formally acknowledged; that the representative council has no right to originate laws, but only to discuss those offered to them by the Council of State; that the right of petition is not recognized, and that the privilege of voting is possessed only by those who pay a certain amount of taxes; the amount being fixed so high as to exclude about two-thirds of the citizens who are over age from the polls.*

* All this has been changed by the constitution adopted May 24, 1847, the provisions *whereof* are essentially democratic.

Take the agitation of this canton in connection with the fact that in the eight cantons having a popular form of government, there were no revolutions in 1830, the last marked period in the progress of these governments, and the lesson becomes even more instructive.

How much do we not owe to our forefathers, who in establishing our republican system threw off the trammels of the Old World, and removed all such obstacles to our progress! How clear their view of republican institutions when compared with those of the men of Europe, even in the present day!

One of the most important engines in the improvement of Switzerland is the "Helvetic Society for public utility."* Its branches are scattered over the whole country, meeting frequently and maintaining a correspondence with the parent society through the medium of committees. Delegates from the local associations meet in different parts of the country in turn, and discuss questions connected with education, political economy, and the general welfare of the country. The reports made at these meetings and the information laid before them are printed and disseminated through the confederation by the branch societies. Independently of the influence thus exerted upon and through the reading community, the intercourse of enlightened men of different cantons is beneficial to the country, and the congregation of great and patriotic spirits has a good effect in the place of meeting. In the summer of 1837 this society met at Geneva, and then for the first time some of the statesmen of the German cantons met their fellow-citizens of the French frontier. The first meeting in the illuminated botanic garden, the mornings in the representative hall devoted to discussions, the general meetings for meals, the soirées and suppers, each served in their place, (for the Swiss, like the English, Germans, and Americans, love good cheer,) to promote the objects of the meeting. The subjects discussed in the council hall, show exactly the point to which the country has advanced. They were the importance of agricultural schools, and of schools for teachers, of saving-banks or funds, and the question whether those who in time of plenty (like the Pharaohs of old) hoard up grain to sell it at an advance in seasons of scarcity should not rather be considered benefactors of the public than objects of mob violence. The influence of high character was beautifully illustrated in one of these morning meetings. A warm debate had arisen upon the report of a committee proposing to establish schools under the direction of the society. The more the subject was discussed the further men's opinions appeared asunder. The keen politician of Geneva, with French vivacity, had made his declamation and ended with a phrase; the enthusiastic clergyman of Vaud, with somewhat of the old Calvin fire, had replied; the veteran philanthropist of St. Gall had laid down the doctrine by which he intended sturdily to abide. Union seemed impossible and discord probable, when there rose, near the president's chair, a man

* *Gemémnitzige Gesellschaft.*

heavy in countenance and in person, with an embarrassed air and awkward address, the words of his first few sentences of miserably pronounced French coming forth slowly, and almost by stammering. The natural reflection of a stranger would have been, why does that stupid man rise; what light can he expect to throw upon the question? Not so, thought his countrymen. They knew the mind that occupied this unpromising exterior, and all listened with entire attention to Hess, the burgomaster of Zurich, while by his own moderation he stifled the flame which had been burning so fiercely, and by his good sense united all the friends of education on a common ground of conciliation and compromise. The denial of self shown by thus using a language which was not familiar to him produced, also, doubtless a favorable impression. Those who afterward heard the same speaker in his vernacular rousing an assemblage by his eloquence, or moving them to laughter by his wit, must have found it difficult to recognize in the accomplished orator the embarassed speaker of the representative chamber.

The canton of Geneva contains fifty-six thousand inhabitants, thirty thousand of whom live in the town. The adjoining canton of Vaud presents a striking contrast in this as in other respects, out of one hundred and eighty thousand people, only fourteen thousand being inhabitants of Lausanne, the capital, and only considerable town in the canton.* The people of Vaud pride themselves upon their ultra-republicanism, their orthodoxy in religion, their present moral and social condition, and the broad basis laid in their institutions for further improvement; the carrying out of the cantonal motto of "liberty and country." Their constitution declares the sovereignty of the people and the equality of all citizens in the eye of the law, guarantees individual liberty, the right of property, the inviolability of domicile, the freedom of the press, and the right of petition. It provides for the separation of the legislative, executive, and judicial authorities, a feature so universal in our constitutions that we are surprised to find it generally overlooked by the framers of the Swiss. All citizens have a right to vote at twenty-three years of age. The church is, as in all these countries, connected with the state, and is styled in the constitution the National Evangelical Reformed Church. Worship according to the forms of the Roman Catholic Church is guaranteed to some of the communes, and there this church is also connected with the state. The voluntary church system as it exists with us is almost unknown, and it would be difficult to imagine the first effects of severing church and state among a people where the connection has always existed; yet some of the clergy of Vaud look to the separation as conferring a desirable freedom upon their church. As evidences of the moral condition of Vaud may be mentioned that in 1836 there was

* The census of 1870 gives to the canton of Geneva a population of 89,416, whereof about one-half live in the city proper. According to the same authority, the canton of Vaud has a population of 229,596, and Lausanne 25,000.

but one criminal for every one thousand seven hundred and eighty inhabitants; while in Massachusetts, also an agricultural community, there was last year one criminal in one hundred and fifty; and counting only natives of the State, one in seven hundred and fifty. These people have laid broad and deep the foundations of improvement in an admirable system of public instruction, combining, as all are of one mode of faith, religious and intellectual culture. The law declares that the happiness of a people is to be found in good morals and good instruction, and that in a free country every citizen should have put within his reach an education fitting him for his rights and duties. It has not stopped at any point in public education, saying you of a certain class shall have such schools, and you such others, but has divided the schools according to the age and attainments of the children, and, for those on the threshold of active life, according to the probable future pursuit of the individual. Thus they have elementary schools, middle or industrial schools, a college, a university, and schools for male and female teachers. In a canton where suffrage is universal, the legislature has had the boldness to require that all children from the age of seven to sixteen shall be under instruction, unless capable of passing a certain examination. Parents who neglect or refuse to send their children to school are cited before the authorities and fined; in case of a repetition of the offense may be imprisoned, and thus deprived for a time of the rights of citizenship. Whether this provision can be fully executed or not yet remains to be seen; at present it is a salutary stimulus to the negligent. The ground of its adoption is, that universal suffrage requires universal education, and that as the law guarantees to citizens the one, it has a right to demand of them the other. The middle or industrial schools are colleges for business men preparing for the pursuits of commerce and the mechanic arts, and bearing the same relation to these pursuits that the colleges do to the professions of medicine, law, and theology. The canton has a school for the deaf and dumb, and one for the blind at Yverdon.

The prison discipline, like our own, puts in action the benevolent idea of reforming the delinquents; but the horror of solitary confinement which appears to exist in the mind of every one allied, even remotely, to the French has marred the system both in Lausanne and at Geneva. Happily the care which is taken in collecting the statistics of the prisons must gradually lead to a change. Finding that there are as many cases of recommitment now as under the old arrangement, they will see that with the gregarious system, even with work, there can be no reform.

This canton was the last scene of the labors of the great reformer in education, Pestalozzi. At Yverdon, on the shores of Lake Neufchatel, in a castle erected for war, but turned to purposes of peace, he terminated his active, beneficent, but stormy life. He was the Bacon of education. Adhering rigidly to the laws of induction, he changed the very basis of the sciences. He combined those extraordinary qualities

of the German character, simplicity, enthusiasm, rationalism, and its opposite, mysticism. As a practical teacher he has been surpassed by many of his followers, but he was undoubtedly the founder of a new school in education. Restless, and always dissatisfied with the results of his efforts, he began many times afresh, and to the last, with renewed hope of entire success. Unqualified to manage pecuniary matters, his mind was always oppressed with the details of the economy of his schools as soon as they became large. Prussia owes the present improved condition of her burgher or citizen schools—for her "schools for the poor"—are *poor* indeed to the precepts and examples of those who drew both from Pestalozzi. A school nominally conducted upon his principles is still kept up in the old castle, but resembles much the deformed copies from the same model which we have seen in this country.

Before leaving the southern part of Switzerland, let us pass for a few minutes into the canton of the Valais and among the Alps, not to admire scenery but to observe Swiss enterprise. Railroads are out of the question in such a country, and places for canals are rarely to be found, but improvements peculiar to the country take their places, and require both skill and originality.

In one of the narrow valleys of the Valais, a tributary to the Dranse (itself a branch of the Rhone) takes its rise in the melting snows of the glacier of Getroz. This mass of snow and ice is formed by the accumulation of snow upon two mountain flanks, which, descending and uniting in the gorge, are slowly pushed forward into the valley, melting as they advance, and feeding with innumerable rills the turbid Dranse. In the spring of 1818 the waters of the stream were very low, and as this circumstance had preceded a dreadful inundation of the valley of Bagnes in 1595, the peasants taking alarm moved up the valley to ascertain the present cause. They found that the fall of large blocks of ice from the glacier of Getroz, and of avalanches from the mountain sides, had completely dammed up the waters of the Dranse. The icy barrier is described to have been four hundred feet high, six hundred feet wide at the top, and three thousand feet at its base; the lake behind it was a mile and a quarter long, and at the barrier some fifty fathoms deep. The waters in this basin rose at the rate of two feet per day, and it was almost certain that finally, rising to a height capable of bursting the wall of ice which held them in, they would in their mighty rush sweep the valley to the very banks of the Rhone. The engineer of the canton, M. Venetz, made a bold attempt to prevent this disaster, which, if it did not entirely succeed, greatly diminished the dreaded devastation. A tunnel through the ice was commenced at a sufficient height above the swelling waters to prevent their reaching the laborers before its completion. Two sets of workmen labored day and night for nearly a month in its formation. When first finished it was not of sufficient size to prevent the rise of the lake, but widening and deepening

om the flow of water through it, in thirty-two hours it had drained ff ten feet in depth of the lake, and in twenty-four hours more, twenty eet. More than one-third of the water had thus escaped when the ction of the issuing cataract upon the base of the mound had so far eakened it by detaching large masses of ice, that the barrier was sud-lenly burst asunder. With a dreadful noise the liberated waters took heir way down the valley in one mountain wave, carrying before them normous rocks, the forest and hill-side, fields, fruit-trees and fences, ridges and châlets, and furrowing or covering the low grounds with he débris of the mountains. The destruction is represented to have een terrible, in all but that of life approaching that of the previous atastrophe. The energies of this simple people were but for a time aralyzed by this dire misfortune, and means were almost immediately ıken to repair its effects and prevent its recurrence.

Captain Hall, who visited the scene just after the disaster, and again fter an interval of fifteen years, thus speaks of the first appearance nd of the change which industry had wrought during the interval: We said to ourselves, that no time could ever restore their town (Marigny) to prosperity, or reclothe their fields with verdure. Yet, only fteen years afterward, when I again visited this scene of utter, and, s it seemed, hopeless desolation, I could scarcely by any effort of the magination recall the spot to my mind, or be persuaded that it really vas the same ground I had seen laid waste. * * * * The fields were all again thickly matted with verdure; the hedges and lividing walls appeared never to have been disturbed; flower-gardens ınd kitchen-gardens and grass-plots smiled on every side of this happy valley; apple-trees, laden with fruit, and rows of tall poplars marked ›ut many lines of new and better roads than before, leading from new bridges which formerly had no existence." The date of the first disaster was found inscribed upon a beam in one of the châlets, accompanied by a set of letters; the whole may be thus paraphrased: M. O. E. | 1595. | W. B. W. D. B. | T. G. O. G. The puzzle has been thus deciphered by a Swiss Monkbarns: Maurice Olliet erected, 1595, when Bagnes was destroyed by the glacier of Getroz.

Friburg lies between Vaud on the south and Berne on the north. It was the ninth canton admitted into the confederation. From having been the most aristocratic of all—some sixteen families governing seventy thousand people—it is now almost as liberal as Vaud. Suffrage s universal and the press is free. The religion of the state is Roman Catholic, the bishop still retaining the title of Bishop of Lausanne and Geneva. Party spirit, probably, run higher in this canton than in any ›ther. The old aristocracy has its friends, though in the minority. The republicans, who triumphed in the revolution of 1830, excluded the clergy from the councils, but their influence still maintains a party there, and the church itself is divided between the rival influences of the Cordeliers and of the Jesuits. There are nine convents in the canton, a lyceum

or college and a boarding-school, in the capital. The clergy have not abandoned the claim, though deprived of the power to direct the secular instruction of the people, to license and displace their teachers. The struggles of these parties and influences keep up a constant political excitement.

It is difficult for a stranger who approaches the town of Friburg from the French cantons, on a day when the weekly fair is held, to believe that a scene of real life is before him. The old battlemented walls, with their towers, carry us back to the days of arquebusses and culverins, or even to those of cross bows and catapults. The collection of peasants in the square, clad in the varied and picturesque costumes of the adjoining districts, keeps up the illusion. It is easy to realize that such looking people should sing and dance, but that they should buy and sell in earnest is not so easily credited. There is some poetry left yet in the exterior of life, at least in these countries. This thought was again awakened on finding myself in the cell of a monk in the convent of the Cordeliers. The vaulted ceiling, grated door, bare walls, the pallet bed and rude table, with missal and crucifix, the occupant clothed in coarse black serge, the cord of his order passing around his waist, produced a most singular effect. There was nothing in the manners and conversation of the venerable Father Girard to dispel any illusion created by the circumstances around him, unless the faintest possible tinge of the world, such as he may have got while superintending the schools of his canton just after the revolution of 1814. Hoping to dull the edge of party spirit which he supposed attacked the schools because a Cordelier was at the head of them, he retired into voluntary exile for ten years, and returned, at the age of seventy-two, to die, as he said, at home, when his years would be an apology for not mingling in public affairs. He had returned to find his schools in incompetent hands, almost in decay, and his normal school, from a similar cause, on the point of being abolished. Imbued with the spirit of Pestalozzi, Father Girard gives to the languages as instruments for intellectual training the part which the great master assigned to the sciences; for economy's sake he adopted the monitorial system, but hoped to see the time when it might give place to a better. In his retirement his influence with the intelligent men of Switzerland was very great, and was exercised to forward the intellectual progress of his country. "I love all men with Christian hearts, though they may not be orthodox in formulary; such is my profession of faith," was the catholic sentiment of this truly good man, reminding me of the beautiful lines of Wordsworth, written at Friburg:

"Doom'd as we are our native dust
To wet with many a bitter shower,
It ill befits us to disdain
The altar, to deride the fane
Where patient sufferers bend, in trust,
To win a happier hour.
* * * * * *

" Where'er we roam, along the brink
Of Rhine, or by the sweeping Po,
Through Alpine vale, or champaign wide—
Whate'er we look upon—at our side
Be charity—to bid as think,
And feel—if we would know."

ıe situation of Friburg has afforded opportunity for two pieces of acteristic enterprise. The channel of the river Sarine forms al- t a loop at the town, inclosing it on three sides, and flowing in a sandstone valley. The town occupies the top and sides of the ıontory thus formed, and on the steep slope the tops of the houses w are on a level with the pavement of the streets above. Into this y the road to Berne formerly descended, and mounted a precipitous on the other side of the stream, occupying, with its windings and ılow pace by which it was necessarily traversed, an hour, and to pass one side of the valley to the other, a distance in a straight line of three hundred yards. A beautiful suspension bridge now connects ıpper plateau of the town with a point equally high on the oppo- ɔank, the suspending cables of wire being firmly fastened in the ive rock on either side, and passing over two neat piers of Jura ıtone. This bridge was planned by an engineer of Lyons, but exe- l by Swiss workmen, and entirely with Swiss materials. The road- is eight hundred and ninety-six feet in length between the piers, o and a half times as long as the elegant structure of the same now erected over the Schuylkill at Philadelphia, and once and a as long as the celebrated chain bridge over the Menai Strait in s. The road-way is suspended at the height of one hundred and ıty-four feet above the Saarine, and looking up from the valley the d wire ropes which support the whole resemble mere cords pro- l against the sky, while the upright wires by which the platform s appear like cobwebs. The trials to which this structure was sub- l by the authorities before receiving it were many and severe, the st that of marching across it two thousand people keeping step to e, the measured cadence producing a continually increasing vibra- and trying the strength to the utmost. The successful completion is work and its durability have led to the erection of a second of ame kind at another point of the valley; so that this little town of thousand inhabitants may now boast of two of the most beautiful ges in the world.

rne, the capital of the largest and most populous canton of the s confederacy, is, in appearance, thoroughly a Swiss town of the chool. Its site is a bold promontory, like that of Friburg, nearly ınded by the Aar, a tributary of the Rhine. The appearance of e is very quaint. Entering it from the south, three gateways are d in succession, at intervals from each other, beneath towers which so many epochs in the extension of the walled town. Before the

use of artillery Berne was a place of great strength, the site having been selected in the twelfth century for its military properties, by Berthold, of Zähringen, the founder of the city. The fronts of the houses in the principal streets, as in the Italian towns of the Middle Ages, rest upon arcades, which form covered walks for passengers. The heavy piers of the arcades render the shops dark, but this inconvenience is more than counterbalanced by the protection from the winter's snow in a town almost among the Alps, and at an elevation of sixteen hundred feet above the sea. The streets are provided at intervals with fountains of curious devices and rude execution, in which, besides the figure of *the bear* in various "armor and attitude," are warriors and goddesses, and remarkable above all, the terror of children, the great Kinder-fresser, or ogre, who, with the head and shoulders of one poor innocent in his gaping mouth, in the very act of swallowing, has a bag full of similar choice mouthfuls about his neck, apparently struggling to escape the fate of their comrade. In one of the towers is the famous clock of kindred taste with the ogre. Before each hour a cock flaps his wings and crows a warning. A figure representing Father Time reverses his hour glass, and opens his mouth as if to cry aloud to the careless. At noon is the grand procession of the bears, who, marshaled by knights and soldiers, issue to the sound of music and pass before the figure of Time first on all fours, then half erect, and finally rampant, figuring thus the different conditions of the town of which they are the patrons. The figure now raises a wand and strikes the hour upon a mimic bell, keeping time with the striking of the clock; the cock again flaps his wings, and for twenty-four hours the bears have rest. The regard for bruin in Berne has been the growth of ages. The accidental killing of a bear by the Duke of Zähringen on the day of founding the city placed the effigy upon the coat of arms, and perhaps gave name to the infant city, for Berne signifies bear in the Swabian dialect. The effigy of the bear was connected with the conquests of the warlike burghers, and the living animal kept to amuse the people by his antics. A whimsical old lady left a handsome estate to the town to maintain a family of bears, forever, and in 1798 the animal became associated with the misfortunes of the canton as it had been with its rise and prosperity. The savings from the estate of the bears shared the fate of those of the canton, when the French armies appropriated the thirty millions of specie in the vaults of the treasury. The bears themselves were removed from their ditch and transported to Paris, the huge cage containing the father of the family having upon it the insulting inscription, not yet forgotten by the people, of Avoyer (President) of Berne. One only lived to return to his home at the general restoration of the spoils of Europe, but the bears of the present generation appear to have forgiven or forgotten the sorrows of their parents, and, all unconscious of their own present dependent state, are as diligent in climbing poles, and as active in begging and quarreling for nuts and gingerbread as if the present bear-ditch had always

been the abode of both parents and cubs. How difficult it must be for the men of Berne among the scenes of the Middle Ages, and with history and tradition both fettering them, to keep up with the progress of the times; and yet they have done so in a very great degree, as a glance at the institutions of the republic will show.

In 1785 there were but two hundred and thirty-six families, the members of which were eligible to the grand council, the governing body of a canton of three hundred thousand inhabitants, and of its tributaries, Vaud inclusive. These were the descendants of the original burghers of Berne, and of those whom they had admitted from time to time into their fraternity. Many of them were members of one of the five guilds, the bakers, butchers, tanners, smiths, and carriers, originally an aristocracy of working men. Of the two hundred and thirty-six families only seventy-six were eligible to the executive or lesser council, and twenty of these, by the preponderance of numbers, governed the State. In 1796 there were twenty-two persons of the name and family of Steiger in the grand council, fifteen of Watwyl, and so on. It was certainly no easy task to undo the Gordian knot of such institutions, but the French invasion sundered it, and the complete separation of social and political ties which followed prevented a firm reunion of the parts. A feeble aristocratic government was rëstablished under the protection of Austria, after the French occupation ceased, and was continued until 1830. At this time the revolution of the three days in Paris gave a new impulse to popular institutions by the support which it promised to hold out to their friends. The people of the country parts of Berne met in their arrondissements and petitioned the government for an extension of popular rights. They were answered by prohibiting their assembling. They continued to meet, and the government ordered out the militia to suppress these meetings, and collecting their most trustworthy troops in the town, closed the gates and prepared the cannon upon the ramparts for action against the peasantry. The militia refused to turn out; the troops in the town declared their unwillingness to act against their countrymen. No attack was made, but the government wisely determined on abdication, declaring that on a certain day they would cease their functions if such was the will of the people. This was all that was desired. An assembly was called to frame a constitution, and without any violent shock, in October, 1831, the old aristocratic government gave place to the new republican, in which although there is some leaven of the former aristocracy, it is not sufficient to leaven the lump. This is a true history of a Swiss republican revolution. The new constitution declares the sovereignty of the people, the liberty of the press, the right of the representative council to originate measures, toleration of religion with an established national church. Every citizen is an elector of the first grade; and every hundred of them chooses an elector of the second grade, who votes for the representative council. As in the other cantons, with few exceptions, the

powers of government are mingled, and what strikes an American as even more strange, while the representative council is elected for six years, the judges chosen by them are elected but for five.

One of the first steps of the new government was to reorganize and renovate public instruction. A visit to the normal school established by them must inspire bright anticipations of future improvement for the country. Patriotism, religious and moral feeling, and intelligence, are developed by precept and example in those who are hereafter to have the training of the Bernese youth. The industrious life of these future teachers, eleven hours being spent in the school-room, in receiving or imparting instruction, their frugal fare, meat of any kind being placed before them but twice in each week, and their coarse clothing, are all shared with them by the director of the institution. Severe exercise in the open air, through the gymnastics so popular in Germany and Switzerland, counteracts, in a degree, the effect of this sedentary life upon their health. In addition to the branches usually cultivated in our schools, music is made a part of the teacher's education, that he may, in turn, give instruction in it to all his pupils. The effect produced by the deep toned and well tuned voices of the young teachers in this normal school, engaged in singing, *con amore*, some of the patriotic songs of their country, was one of the most moving that I ever experienced. What a fine material for republicans! was the remark of the counsellor of state who accompanied me, the echo of the very feeling which was thrilling through me. Close by this school is Hofwyl, the celebrated institution of Emmanuel Fellenberg. But to venture within its precincts would occupy you far longer than I am privileged to do. The system of this establishment, for it is not one school, but is composed of several schools of different grades, has served, in a degree, as a model for that of the canton, and has exerted a greater influence in and out of Switzerland than any other single institution in the world.

The new government has reorganized and improved many of the public establishments of the canton, and created new ones. Thus the two orphan houses of the city have already felt its favorable influence; a school for the deaf and dumb, and one for the blind, has been established under its patronage, and a new penitentiary has been erected for the introduction of the modern improvements in prison discipline. In 1819 women condemned for crimes swept the streets of Berne, and now the government is nearly prepared to adopt the Pennsylvania system of prison discipline. Surely the progress of this people has been worthy of, if not above, all praise.

On the eastern side of the town the bank of the Aar is quite precipitous, and from the parapet which crowns it a glimpse is had into the fairy-land, the Oberland of Berne. The peaks of its snow-clad hills, with their bold outline, cut sharply against the sky, presenting, in the course of a clear day, a beautiful variety of aspect, from the dark shadows cast by the rising sun, and the brilliancy of mid-day, to the delicate hues

unset, and the ashy and almost ghastly paleness of the evening. One of the few things which cannot disappoint is a visit to the Bernese Alps. Nature presents itself not only upon a grand scale, but in unusual and varied forms. Lofty and precipitous mountains, rugged with rocks, and ice, and snow; glaciers pushing their way from the steep mountain sides into the valleys; avalanches tumbling headlong from the heights, and with a roar like distant thunder burying their ice and snow in the deep gorges; cascades pouring from precipices so lofty that the water is dispersed in dust-like spray, in mid-air, or tumbling from rock to rock in foaming sheets; pine-clad hills, and valleys green with grass; all these, in turn, rejoice the sight, while the unaccustomed modes of Alpine traveling invigorate the frame, and the spirits rise until they create a world of enjoyment of their own. The works of man lend themselves to nature, to add to the picturesque character of these regions; for the Swiss cottage, with its roof weighted with stones, its projecting eaves and out-door galleries, is unlike a farm-house elsewhere, and the châlet, with its stable, dwelling, and dairy, all under one roof, yet separated with scrupulous regard to neatness, is as unlike a peasant's hut. The costume of the people, too, puts them to the eye of a stranger in constant masquerade, and the vocal music, with its curious falsetto tones, and the instrumental upon the wooden tube, or Alpine horn, are unlike what is to be heard in other countries.

The valley of Grindelwald is itself more than three thousand feet above the level of the sea, and from it the Faulhorn rises three thousand more. The ascent of this mountain is by winding paths, along the base or on the brink of high rocks, by the side of ponds formed by the melting snow, through the snows themselves, to the very apex. Then the whole district of the lakes of Brientz and Thun is stretched out before and far below you, the lake of Lucerne and its mountains, the valleys of Lauterbrunnen and Grindelwald, the Alpine heights of the Eiger, the Monk, the Jungfrau, and others of this chain, far across to the mountains where the Rhine and the Rhone both have their sources. Above the region where the white hill-clouds of summer are formed and rest, when *they* occur spreading a deep shade over the valleys below, the top of the Faulhorn is in the full blaze of the sun, and the eye ranges from it upon the expanse of the tops of the white clouds, as over a vast plain of snow thrown into ridges by the wind, a mimic ocean of snow with the forms of waves without their motion. Life in a châlet upon such a mountain is very little like that in an inn down in the valley. The whole mountain-top will hardly give elbow-room to the twenty or thirty people who come up on a fine summer's day, much less will the châlet give room for exclusiveness in eating, drinking, or sleeping. Then, further, to break down reserve, the sunset is to be seen by all, and then the moon, at rising or setting, puts the whole sleeping household in motion, and again all are out to see the sun rise over the distant Alps.

There are some traits by which one may infallibly recognize our coun-

trymen, and in this châlet with us was an undoubted American. He talked to every one who could speak his vernacular, and spoke to every one who would give his broken French an answer. His meals were bolted down in haste. He fidgeted lest he should lose anything of the moon or sun rise, and actually turned out to witness the former in regular Kickapoo style, wrapped in a blanket. He was restless to an excess, and talked all the time that others were absorbed in sentiment; forgetting his unpresentable condition, he even addressed some young English ladies, who had certainly offered no special encouragement to the approach of any fellow-traveller, even in full costume. He was off among the first in the morning, and after the day's journey we met him in the evening at Meyringen, still talkative as ever, and his tones certifying that he came from the east of the Hudson; so far, the very beau-ideal of the American figured by tourists. Here, however, he piqued my curiosity by the very un-American act of abusing the supper, as well as by some peculiarity of expression; and, entering into further conversation with him, I found that this *undoubted* American was last from Thread and Needle street, had been born and bred in the old country, and had not even trodden our republican soil. So much for national characteristics, which, like family peculiarities, may sometimes lead us to mistake the father for the son.

On the way from the Oberland to Lucerne we pass a work of improvement well worthy of notice. At the foot of the Brunig Mountain, on the north side, is the small lake of Lungern, draining the slopes of a basin of moderate extent, and having originally no outlet. It is separated by a mountain ridge from the lake of Sarnen, which communicates with the lake of Lucerne. Lake Lungern is some four hundred feet higher than Lake Sarnen, so that by establishing a communication between them the former might be drained to any required amount, and arable land be thus gained upon the lake shore. A tunnel to establish this connection was begun in 1788, and after many delays was completed in 1836, at the cost of $25,000, and nineteen thousand days' work by the peasants. The winter season, when the lake is lowest, was chosen for completing the tunnel by breaking through a rocky barrier into Lake Lungern. The undertaking succeeded, and in ten days the water fell to the level of the mouth of the tunnel. A new and unforeseen danger now threatened the people of the village on the lake shore. The bank, no longer supported by the water, and exposed to the action of the frost, began to crack, and the earth separating from the underlying rock, threatened to precipitate the church and part of the village into the lake. In fact a slide did take place, but only to a limited extent, and by cutting the shores in terraces the progress of the evil has been stopped, and the gain of about five hundred acres of arable land may be considered as permanent.

The town of Lucerne, the capital of the canton of the same name, and formerly in rotation with Berne and Zurich, the seat of the sessions of the

Swiss Diet, is beautifully situated on the lake of the Forest cantons, on a level piece of ground, at the point where the Reuss issues from the lake to join the Limmat in its course to the Rhine. Lucerne, on a gala day, presents an interesting sight to the stranger. When I saw it, the people in holiday dress were collecting from all quarters to the lake side; the long wooden bridges which join the different parts of the town, and the stone-lined quays along the Reuss, were thronged with people pressing toward the same point. The women from the country wearing the hair plaited on the crown of the head, or black caps with mohair lace wings, and long plaits of hair and black ribbons falling down the back, accompanied by men in plain attire, all speaking the harsh patois derived from the Southern German. Even the bridge from the Abbey had its passengers, though now few indeed in numbers, and a few Cordeliers were seen mingling with the throng. The windows of the tall houses near the wharf presented an array of the notables of Lucerne, and even some members of the diet might be pointed out to the stranger. The bells were ringing at intervals, and cannon pointed toward the lake were prepared for a salute. The American smiles complacently when told the cause of all this circumstance. The first steamboat navigating the lake is expected on its first return trip from Altdorf, and even now may be seen rounding a neighboring point. The excitement increases as the wonderful boat approaches, and we are carried in imagination back to the days of 1807, when New York poured out its population to greet the return of the first adventure of the great Fulton. No doubt now mingles, as then it did, with expectation, and amid the hoarse noise of loud German exclamations and hurrahs, and the discharge of artillery, the boat approaches. It is wonderful to see how at once the art of managing the vessel has been acquired! How imitative a creature man is! The captain is mounted upon the wheel-guard directing the pilot and engineer with his hand. The headway is checked judiciously, and now the boat nears the wharf. With what precision and skill this manœuvre is executed for the first time! The thought is hardly complete, when rising loud and clear above the hoarse gutturals of the mob, comes to do away all mystery, to explain the whole, in good home-spun English, the well-known cry of "Stop her!" The engine was built in England, put up by Englishmen, and is now managed in its first trial by them; and thus the mechanics and manufacturers of that great nation lay not only Switzerland, but all the continent of Europe, under contribution, as a return for the money spent abroad by her travelers.

The Swiss Confederacy is, politically considered, even a weaker government than ours was under the old Articles of Confederation; at all events weaker for every purpose not merely military. The act of confederation now in force dates from 1815, and all the attempts made since its adoption to modify it so as to produce a stronger government, by cementing the union more closely, have failed. The cantonal spirit resists the least encroachments upon its independence. The act of con-

federation guarantees to each canton its liberty, its independence, its safety from foreign aggression, and peace and tranquillity within. To maintain this guarantee and to preserve the armed neutrality of Switzerland, a contingent of 33,000 men and $140,000 is required from the cantons in proportion to their population and other circumstances. The modified constitution declared every Swiss to be a soldier, expressing only what is the fact, the military spirit being kept constantly alive from the belief that it is essential to the independence of the country. In case of the invasion of a canton, or of violence against the actual government, the confederation is bound, upon a summons, to an armed intervention; and, in case of necessity, a neighboring canton may lend its aid. This provision has been a fertile source of difficulty, for on the one hand the cantons claim the right of revolution, and, on the other, the diet that of intervention. The cantons have no right to form leagues with each other. No privileged classes may be established in any of them. The transit of articles of merchandise and manufactures, and of the necessaries of life, through the different cantons is guaranteed. Such are the leading articles of the constitution.

The diet is the highest authority of the confederacy, and consists of deputies from the twenty-two cantons, who vote, unless specially invested with discretionary power, according to instructions derived from the cantonal governments. Each canton has one vote in the diet. The regular meetings of this body are held yearly, and the senior deputy of the canton where the meeting is held presides. Executive power during the recess of the diet may be vested in the authorities of the canton where the meeting of the year is to be held, or in a special executive council. The diet declares war and makes treaties of peace and alliance; such measures requiring a majority of three-fourths of the votes.*

In the summer of 1837 the diet met at Lucerne. The stormy session of the year before at Berne, in which they had borne themselves so gallantly in opposition to the demands of France, was still fresh in the recollection; but with the adjustment of the difficulties the excitement produced by them had subsided. On that occasion it was said that Switzerland had spoken even in a boasting tone, or, in the language of the French journalists, as if she were a first-rate power instead of a fourth. The national feeling which dictated this tone may be explained and felt by the remark of Professor Monnard, of Vaud, by whom the

* The foregoing remarks apply to the political condition of the Swiss Confederation previous to the 12th of September, 1848, when the revised federal constitution now in force was adopted. This instrument is very similar to that of the United States, only paying somewhat more deference to states rights, and vesting the executive power in a cabinet (federal council) elected by congress in joint session, the chairman whereof being denominated President of Switzerland. The legislative authority is vested in a federal assembly, (congress,) composed of a national council (house of representatives) and a staenderath or States council, (senate;) the supreme court and executive authority being both elected by the federal assembly or congress, in joint session, in which is vested the supreme power of the land. Berne is the permanent capital.

threatening language was spoken, "we cannot recognize a first-rate and a second-rate national honor."

There is still something of the "feudalism of democracy," as a distinguished author has called it, in the ceremonies of the diet, walking in procession to their hall where their deliberations take place, wearing cloaks embroided with the arms of their cantons, and even of more than one color, received by double rows of guards, and deliberating with swords by their sides. The antiquated costumes are destined to disappear with many feudal forms, but the delegates from those cantons, the democratic, where the least change has taken place in their institutions, are wedded to their old garments as well as to the old constitution. In the hall of meeting twenty-one seats are arranged about an oval table for the senior representatives, the president having his seat at the one extremity of the table, and the consulting deputies occupying small tables in the rear. The members do not rise when addressing the chair, which has an awkward effect, and must be embarrassing to the lively delegates of the Italian and French cantons; but all minor embarrassments yield to that of the use of three different languages, the French, German, and Italian, by members from the different cantons, while a majority of the deputies understand but one. A glance at these representatives will illustrate the difficulties of forming a Swiss union. What has the man of Tessin really in common with him of Geneva? The one is a Roman Catholic, the other a Calvinist; the one a republican of the most democratic school, the other an aristocrat by principle, and perhaps by birth; the one is from a rough pastoral or agricultural district, the other from a city where the more refined mechanic arts flourish; the one from a small community, all the members of which are nearly equal in the means of life and in education, the other from a town where wealth and education are very unequally distributed; the one in speech an Italian, the other a Frenchman. Again, what has the educated and polished professor of Lausanne, or the merchant and banker of Basle, in common with the peasant of Appenzele or the shepherd of Uri? With all these diversities they are brought together in part by a sentiment—the love of liberty; in part by a necessity—that of mutual defense. The progress of the cantons in education and the arts of life will doubtless draw their bonds gradually closer, and to have attempted a union in 1832 is to have laid the basis for it at some other time. Meanwhile the confederation, if it does not directly aid the cantons in their career of improvement, at least goes far to guarantee the continuation of that peace which is essential to progress.

Let us turn our backs upon the mountains, to glance merely, for that is all that can be attempted, at Zurich, one of the cantons of the plain, if any part of Switzerland can be called a plain; one of the farthest advanced of all in the mechanic arts, manufactures, education, and good government. Here the republican change was brought about in 1830, by a simple change of administration, the council not being required to

abdicate as at Berne, and up to this time a struggle for power goes on between the partisans of a former order of things and the clergy against the new order, and, from time to time, one or the other influence prevails. The canton, meanwhile, steadily advances. Suffrage is universal; the right to vote beginning at twenty years of age.

The progress of the canton since the new order of things may be best illustrated by a few facts. The press is free, the legislative, executive, and judicial departments have been separated, public instruction has been set forth as one of the first duties of the state, and invasion of domicile has been declared unlawful. To these intellectual improvements may be added physical or material ones; good roads have been made throughout the canton and stage coaches put upon them, so that instead of ten or twelve people leaving Zurich, or entering it, per day, there are now one hundred and ten. The poor tax is at the rate of but 5 cents per annum for each citizen inhabiting the canton; the church rate 18 cents; and the expense of the civil list 20 cents. Finally the revenue in 1832 exceeded the expenditure by $100,000, and this surplus has been devoted to the cause of material and intellectual improvement.

From the hasty and imperfect glance which we have now taken together of republican Switzerland, what conclusion may we draw as to the capacity of the principle which connects these people, to produce their happiness, their moral, intellectual, and physical improvement?

In the distance which separates us from them the minuter shades of character are lost. We do not discern the men of Geneva, of Vaud, of Berne, and of Zurich, but the men of Switzerland. Standing out from the picture, like the lofty summits of their own mountain chains, are the prominent characteristics of the people. Frugality, perseverance, hardy enterprise, high moral and religious feeling, lofty patriotism; these are the characteristics of the Swiss nation.

How far these noble qualities are the result of their political institutions, or whether the institutions owe their origin to these very qualities of the people, it is needless to inquire, since what greater praise can be awarded than the truth, that the institutions of Switzerland are in harmony with the free spirit of the people, and the spirit of the people with their noble republican institutions.

ON A PHYSICAL OBSERVATORY.

By Prof. Joseph Henry.

Smithsonian Institution,
Washington, December 29, 1870.

My Dear Sir: Yours of the 28th of November was duly received, but I delayed answering it until the pressure of business which accumulated during my absence should have somewhat subsided, and, also, that I might receive the plans which you mention. I am now gratified in being able to inform you that my visit to Europe was both pleasant and profitable, and that I have returned much improved in health and with enlarged views as to the present state of science in the Old World.

While abroad I gave special attention to physical observatories, of which there are several in England and on the continent, although there is no one which fully realizes my idea of what such an establishment ought to be.

A physical observatory is one the primary object of which is to investigate the physical phenomena of the earth and the heavenly bodies in contradistinction to an ordinary astronomical observatory, which is principally devoted to the observation and discussion of the motions of the planets, and the determination of the relative positions of the fixed stars. Of the latter kind but one or two are needed in any country, and as these require a numerous corps of observers and computers they can only be supported by appropriations annually from a national government. The United States Observatory at Washington is of this character, and, including all expenses, requires an annual appropriation of at least $50,000. The labors of such an observatory are indispensable to the advancement of the science of theoretical astronomy, and its application to geodesy and geography.

The establishment I would advise you to found is of the character of the one first mentioned, namely, a physical observatory, the principal object of which would be, as I have indicated, to investigate the nature and changes of the constitution of the heavenly bodies; to study the various emanations from these in comparison with the results of experiments, and to record and investigate the different phenomena which are included under the general term of terrestrial physics.

A wide field has been opened for the study of the nature of the sun and other heavenly bodies by the application of the spectroscope, different modifications of the telescope, and other lately invented appliances. We now know that the sun is undergoing remarkable changes, the character of which can only be ascertained by the results of accurate observations compared with those of experimental investigation. The observer

should divide his attention between the phenomena revealed by a critical and continued examination of the sun and the production of similar phenomena in the laboratory. In this way European investigators have arrived at most interesting results.

Again, we know that the emanations from the sun, and probably from the stars, differ essentially in character. There is, first, the emanation known as light, which of itself consists of various rays, which generally indicate the incandescence of substances, which give the sensation of different colors, and those which, in their ordinary condition, are imperceptible to the eye, but which may be perceived by that organ after they have passed through certain liquids; next, the heat emanation, which is also of different kinds; then the chemical emanation, by which photographic impressions are produced; and, lastly, the phosphorogenic emanation, which abounds also in the electric discharge, and which produces the glow of the diamond and the luminosity of the compounds of lime, barium, and other substances with sulphur. To study these or other emanations as they may appear in the fixed stars, or are reflected from the moon and planets, or as they may be found in the aurora borealis, the zodiacal light, and in shooting-stars or larger meteors, requires peculiar instruments, and such as are not found, at present, in ordinary astronomical observatories. For example, the celestial phenomena which address themselves to the sense of sight are studied by means of refracting telescopes, as are, also, those of the photographic ray, although this requires a peculiar form of lens, while the heat-ray of lower intensity and the phosphorogenic ray are not transmitted by glass; the former is readily converged to a focus by a lens of rock-salt, and the latter by one of quartz. They may all, however, as in the case of light, be concentrated into foci by metallic reflectors.

In regard to terrestrial physics, the phenomena are also various, and the forces by which they are produced are constantly changing both in intensity and, in some cases, in direction. We now know that the magnetism of the earth scarcely remains the same from one moment to another, and that these changes are connected with the appearance of the aurora borealis and electrical discharges in the atmosphere. They, also, in all probability, may ultimately be referred to disturbances produced by external influences, such as those from the sun, moon, and planets. Furthermore, we may now consider the whole earth as an immense conductor charged with negative electricity, of which the intensity is in a continued state of change, and of which a knowledge of the laws, as well as those of the changes of magnetism, is highly desirable. For the proper study of these, continuous self-recording instruments are necessary.

There is also an important field of observation in regard to ordinary meteorology, such as the changes of the pressure of the atmosphere and its connection with other phenomena; of the normal and abnormal winds; isolated currents of the atmosphere, and especially those of a

ertical direction; the radiation of heat from clouds and different ter-
estrial surfaces; the variation of its intensity in ascending above and
enetrating below the surface of the earth, &c. In short, the field is
lmost boundless, and every year reveals new facts in terrestrial and
elestial physics, which never fail to furnish new points for investigation
) those who are qualified by education and endowed by nature for
ieir proper appreciation.

The conductor of an observatory, such as I have mentioned, to be
uccessful, must have peculiar characteristics. He must possess a
inute knowledge of all the latest discoveries in physics, a keen eye to
etect new appearances, imagination to suggest hypothetical causes,
)gical power to deduce consequences from these to be tested by obser-
ation or experiment, and ingenuity to devise apparatus for verifying
r disproving his deductions. When *such* a man is found he should be
onsecrated to science and fully furnished with all the implements
ecessary for the prosecution of his researches, those of physics as well
s of astronomy, and himself and family placed beyond all anxiety as to
he supply of their necessary wants. It may not be amiss to combine
vith his studies and duties, in the way of research, a small amount of
ecturing—just enough by sympathetic communication with admiring
upils to fan, as it were, his enthusiasm, and to impart a portion of it to
thers. He should also have at his command a skillful workman, who,
nder his direction, could construct the temporary apparatus which are
onstantly required in original research. It is also important that he
e associated with the faculty of a well-endowed college or university,
o which he will become an important acquisition both in regard to the
eputation which he will give to the institution, and the effect he will
ave on the other members of the faculty in the way of stimulating
hem to higher efforts. In such an association he can call for the coöp-
eration of the professors, and especially that of the physicist, the
hemist, and the mathematician.

One of the most important points, perhaps, to which I should call
your attention is that of the building to be erected, since, from the ten-
dency to error in this line, more injury has resulted to public institu-
tions in this country than from any other cause. It should be recollected
that "money is power;" that every dollar possesses a definite amount of
potential energy, as it were, which can always command intellectual or
physical labor. But money as a power is unlike all other kinds of power,
in that it is, by judicious investment, capable of yielding a constant
supply of energy, in the way of interest, without diminishing the origi-
nal amount. It is, therefore, in the highest degree injudicious in the
founding of an establishment to exhaust the source of its power by
architectural displays not absolutely required, and which may forever
involve a continual expense from the remaining funds to keep them in
repair. As a general rule, the buildings of educational or scientific in-
stitutions should be gradually evolved from the experience and wants

of the establishment, and not, as is too frequently the case, from *a priori* misconceptions of those who have no adequate idea of the uses to which the structure is to be applied. It should be impressed upon the public that *buildings* do not constitute an institution, and that reputation and usefulness in science do not flow from visible and tangible manifestations, but are the immaterial fruit produced by the spirit of an organization. I trust that millions of human beings yet unborn will be familiar with the intellectual results of your observatory, although a single inquiry may never be made as to the style of the building in which these results have been produced.

My advice, then, would be: first, if possible, that the right man be procured for director; secondly, that the principal instruments be constructed under his supervision; and, thirdly, that the operations be commenced in an inexpensive wooden building, which will be found better in many respects for physical and astronomical observations than one of stone and brick. The instruments could be insured, I should think, at a small premium, and in that case, if destroyed by fire, might be replaced by others embracing the improvements which may have been suggested in the mean time.

As an illustration of what I have just said in regard to the building, I may mention that in a visit to Mr. Lockyer I found him carrying on a series of observations which have challenged the admiration of the world in a temporary structure made of rough boards, unplastered, and scarcely including a space of fifteen feet square.

As to the location of your observatory, you will infer from what I have said that I think it important to connect it with some well-endowed and well-established college or university.

JOSEPH HENRY,
Secretary Smithsonian Institution.

To ——— ———.

THE HISTORY OF MY YOUTH: AN AUTOBIOGRAPHY OF FRANCIS ARAGO.

[To keep up the series of publications of eulogies of distinguished men, which has been a special feature of the Appendix to the Smithsonian Reports, the following autobiography and the eulogies of Herschel and Fourier are copied from the volume, now out of print, of the translations by the late Admiral Smyth, the late Rev. Baden Powell, and Prof. Grant, from the works of Arago.—J. H]

I have not the foolish vanity to imagine that any one, even a short time hence, will have the curiosity to find out how my first education was given, and how my mind was developed; but some biographers, writing off-hand and without authority, having given details on this subject utterly incorrect, and of a nature to imply negligence on the part of my parents, I consider myself bound to put them right.

I was born on the 26th of February, 1786, in the commune of Estagel, in ancient province of Roussillon, (department of the Eastern Pyrenees.) My father, a licentiate in law, had some little property in arable land, in vineyards, and in plantations of olive trees, the income from which supported his numerous family.

I was thus three years old in 1789, four years old in 1790, five years in 1791, six years in 1792, and seven years old in 1793, &c.

The reader has now himself the means of judging whether, as has been said, and even stated in print, I had a hand in the excesses of our first revolution.

My parents sent me to the primary school in Estagel, where I learned the rudiments of reading and writing. I received, besides, in my father's house, some private lessons in vocal music. I was not otherwise either more or less advanced than other children of my age. I enter into these details merely to show how much mistaken are those who have printed that at the age of fourteen or fifteen years I had not yet learned to read.

Estagel was a halting place for a portion of the troops who, coming from the interior, either went on to Perpignan, or repaired direct to the army of the Pyrenees. My parents' house was therefore constantly full of officers and soldiers. This, joined to the lively excitement which the Spanish invasion had produced within me, inspired me with such decided military tastes that my family was obliged to have me narrowly watched to prevent my joining by stealth the soldiers who left Estagel. It often happened that they caught me at a league's distance from the village, already on my way with the troops.

On one occasion these warlike tastes had nearly cost me dear. It was the night of the battle of Peires-Tortes. The Spanish troops in their retreat had partly mistaken their road. I was in the square of the vil-

lage before daybreak. I saw a brigadier and five troopers come up, who, at the sight of the tree of liberty, called out, "*Somos perdidos!*" I ran immediately to the house to arm myself with a lance which had been left there by a soldier of the *levée en masse*, and placing myself in ambush at the corner of a street, I struck with a blow of this weapon the brigadier placed at the head of the party. The wound was not dangerous. A cut of the saber, however, was descending to punish my hardihood, when some countrymen came to my aid, and, armed with forks, overturned the five cavaliers from their saddles, and made them prisoners. I was then seven years old.*

My father having gone to reside at Perpignan, as treasurer of the mint, all the family quitted Estagel to follow him there. I was then placed as an outdoor pupil at the municipal college of the town, where I occupied myself almost exclusively with my literary studies. Our classic authors had become the objects of my favorite reading. But the direction of my ideas became changed all at once by a singular circumstance which I will relate.

Walking one day on the ramparts of the town, I saw an officer of engineers who was directing the execution of the repairs. This officer, M. Cressac, was very young. I had the hardihood to approach him and to ask him how he had succeeded in so soon wearing an epaulette. "I come from the Polytechnic School," he answered. "What school is that?" "It is a school which one enters by an examination." "Is much expected of the candidates?" "You will see it in the programme which the government sends every year to the departmental administration; you will find it moreover in the numbers of the journal of the school, which are in the library of the central school."

I ran at once to the library, and there, for the first time, I read the programme of the knowledge required in the candidates.

From this moment I abandoned the classes of the central school, where I was taught to admire Corneille, Racine, La Fontaine, Molière, and attended only the mathematical course. This course was intrusted to a retired ecclesiastic, the Abbé Verdier, a very respectable man, but whose knowledge went no farther than the elementary course of La Caille. I saw at a glance that M. Verdier's lessons would not be sufficient to secure my admission to the Polytechnic School; I therefore decided on studying by myself the newest works, which I sent for from Paris. These were those of Legendre, Lacroix, and Garnier. In going through these works I often met with difficulties which exceeded my powers; happily, strange though it be, and perhaps without example in all the rest of France, there was a proprietor at Estagel, M. Raynal, who made the study of the higher mathematics his recreation. It was in his kitchen, while giving orders to numerous domestics for the labors of

* With such precocious heroism it is by no means so clear that the author might not have had a hand in the revolution, from which he endeavors above to exculpate himself.

he next day, that M. Raynal read with advantage the "Hydraulic Architecture" of Prony, the "Mécanique Analytique," and the "Mécanique Céleste." This excellent man often gave me useful advice; but I must say that I found my real master in the cover of M. Garnier's "Treatise on Algebra." This cover consisted of a printed leaf, on the outside of which blue paper was pasted. The reading of the page not covered made me desirous to know what the blue paper hid from me. I took off this paper carefully, having first damped it, and was able to read underneath it the advice given by d'Alembert to a young man who communicated to him the difficulties which he met with in his studies: "Go on, sir, go on, and conviction will come to you."

This gave me a gleam of light; instead of persisting in attempts to comprehend at first sight the propositions before me, I admitted their truth provisionally. I went on farther, and was quite surprised, on the morrow, that I comprehended perfectly what over-night appeared to me to be encompassed with thick clouds.

I thus made myself master, in a year and a half, of all the subjects contained in the programme for admission, and I went to Montpellier to undergo the examination. I was then sixteen years of age. M. Monge, jr., the examiner, was detained at Toulouse by indisposition, and wrote to the candidates assembled at Montpellier that he would examine them in Paris. I was myself too unwell to undertake so long a journey, and I returned to Perpignan.

There I listened for a moment to the solicitations of my family, who pressed me to renounce the prospects which the Polytechnic School opened. But my taste for mathematical studies soon carried the day. I increased my library with Euler's "Introduction à l'Analyse Infinitésimale," with the "Résolution des Equations Numériques," with Lagrange's "Théorie des Fonctions Analytiques," and "Mécanique Analytique," and finally with Laplace's "Mécanique Céleste." I gave myself up with great ardor to the study of these books. From the journal of the Polytechnic School, containing such investigations as those of M. Poisson on Elimination, I imagined that all the pupils were as much advanced as this geometer, and that it would be necessary to rise to this height to succeed.

From this moment I prepared myself for the artillery service, the aim of my ambition; and as I had heard that an officer ought to understand music, fencing, and dancing, I devoted the first hours of each day to the cultivation of these accomplishments.

The rest of the time I was seen walking in the moats of the citadel of Perpignan, seeking by more or less forced transitions to pass from one question to another, so as to be sure of being able to show the examiner how far my studies had been carried.*

* Méchain, member of the Academy of Sciences and of the Institute, was charged in 1792 with the prolongation of the measure of the arc of the meridian in Spain, as far as Barcelona.

During his operations in the Pyrenees, in 1794, he had known my father, who was

At last the moment of examination arrived, and I went to Toulouse in company with a candidate who had studied at the public college. It was the first time that pupils from Perpignan had appeared at the competition. My intimidated comrade was completely discomfited. When I repaired after him to the board, a very singular conversation took place between M. Monge, the examiner, and me.

"If you are going to answer like your comrade, it is useless for me to question you."

"Sir, my comrade knows much more than he has shown; I hope I shall be more fortunate than he; but what you have just said to me might well intimidate me and deprive me of all my powers."

"Timidity is always the excuse of the ignorant; it is to save you from the shame of a defeat that I make you the proposal of not examining you."

"I know of no greater shame than that which you now inflict upon me. Will you be so good as to question me? It is your duty."

"You carry yourself very high, sir; we shall see presently whether this be a legitimate pride."

"Proceed, sir; I wait for you."

M. Monge then put to me a geometrical question, which I answered in such a way as to diminish his prejudices. From this he passed on to a question in algebra, to the resolution of a numerical equation. I had the work of Lagrange at my fingers' ends; I analyzed all the known methods, pointing out their advantages and defects; Newton's method, the method of recurring series, the method of depression, the method of continued fractions; all were passed in review; the answer had lasted an entire hour. Monge, brought over now to feelings of great kindness, said to me, "I could, from this moment, consider the examination at an end. I will, however, for my own pleasure, ask you two more questions. What are the relations of a curved line to the straight line which is a tangent to it?" I looked upon this question as a particular

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one of the administrators of thedepartment of the Eastern Pyrenees. Later, in 1803, when the question was agitated as to the continuation of the measure of the meridian line as far as the Balearic Islands, M. Méchain went again to Perpignan, and came to pay my father a visit. As I was about setting off to undergo the examination for admission at the Polytechnic School, my father ventured to ask him whether he could not recommend me to M. Monge. "Willingly," answered he; "but, with the frankness which is my characteristic, I ought not to leave you unaware that it appears to me improbable that your son, left to himself, can have rendered himself completely master of the subjects of which the programme consists. If, however, he be admitted let him be destined for the artillery or for the engineers. The career of the sciences of which you have talked to me is really too difficult to go through, and, unless he had a special calling for it, your son would only find it deceptive." Anticipating a little the order of dates, let us compare this advice with what occurred. I went to Toulouse, underwent the examination, and was admitted. One year and a half afterward I filled the situation of secretary at the Observatory, which had become vacant by the resignation of M. Méchain's son. One year and a half later, that is to say, four years after the Perpignan "horoscope," associated with M. Biot, I filled the place, in Spain, *of the celebrated* academician who had died there, a victim to his labors.

case of the theory of osculations which I had studied in Lagrange's "Fonctions Analytiques." "Finally," said the examiner to me, "how do you determine the tension of the various cords of which a funicular machine is composed?" I treated this problem according to the method expounded in the "Mécanique Analytique." It was clear that Lagrange had supplied all the resources of my examination.

I had been two hours and a quarter at the board. M. Monge, going from one extreme to the other, got up, came and embraced me, and solemnly declared that I should occupy the first place on his list. Shall I confess it? During the examination of my comrade I had heard the Toulousian candidates uttering not very favorable sarcasms on the pupils from Perpignan; and it was principally for the sake of reparation to my native town that M. Monge's behavior and declaration transported me with joy.

Having entered the Polytechnic School, at the end of 1803 I was placed in the excessively boisterous brigade of the Gascons and Britons. I should have much liked to study thoroughly physics and chemistry, of which I did not even know the first rudiments; but the behavior of my companions rarely left me any time for it. As for analysis, I had, already, before entering the Polytechnic School, learned much more than was required for leaving it.

I have just related the strange words which M. Monge, jr., addressed to me at Toulouse in commencing my examination for admission. Something analogous occurred at the opening of my examination in mathematics for passing from one division of the school to another. The examiner, this time, was the illustrious geometer Legendre, of whom, a few years after, I had the honor of becoming the colleague and the friend.

I entered his study at the moment when M. T——, who was to undergo his examination before me, having fainted away, was being carried out in the arms of two servants. I thought that this circumstance would have moved and softened M. Legendre; but it had no such effect. "What is your name," he said to me sharply. "Arago," I answered. "You are not French, then?" "If I was not French I should not be before you; for I have never heard of any one being admitted into the school unless his nationality had been proved." "I maintain that he is not French whose name is Arago." "I maintain, on my side, that I am French, and a very good Frenchman, too, however strange my name may appear to you." "Very well; we will not discuss the point farther; go to the board."

I had scarcely taken up the chalk, when M. Legendre, returning to the first subject of his preoccupations, said to me: "You were born in one of the departments recently united to France?" "No, sir; I was born in the department of the Eastern Pyrenees, at the foot of the Pyrenees." "Oh! why did you not tell me that at once? All is now explained. You are of Spanish origin are you not?" "Possibly; but

in my humble family there are no authentic documents preserved which could enable me to trace back the civil position of my ancestors. Each one there is the child of his own deeds. I declare to you again that I am French, and that ought to be sufficient for you."

The vivacity of this last answer had not disposed M. Legendre in my favor. I saw this very soon; for, having put a question to me which required the use of double integrals, he stopped me, saying: "The method which you are following was not given to you by the professor. Whence did you get it?" "From one of your papers." "Why did you choose it? Was it to bribe me?" "No; nothing was farther from my thoughts. I only adopted it because it appeared to me preferable." "If you are unable to explain to me the reasons for your preference, I declare to you that you shall receive a bad mark, at least as to character."

I then entered upon the details which established, as I thought, that the method of double integrals was in all points more clear and more rational than that which Lacroix had expounded to us in the amphitheater. From this moment Legendre appeared to me to be satisfied, and to relent.

Afterward, he asked me to determine the center of gravity of a spherical sector. "The question is easy," I said to him. "Very well; since you find it easy, I will complicate it; instead of supposing the density constant, I will suppose that it varies from the center to the surface according to a determined function." I got through this calculation very happily; and from this moment I had entirely gained the favor of the examiner. Indeed, on my retiring, he addressed to me these words, which, coming from him, appeared to my comrades as a very favorable augury for my chance of promotion: "I see that you have employed your time well; go on in the same way the second year, and we shall part very good friends."

In the mode of examination adopted at the Polytechnic School in 1804, which is always cited as being better than the present organization, room was allowed for the exercise of some unjustifiable caprices. Would it be believed, for example, that the old M. Barruel examined two pupils at a time in physics, and gave them, it is said, the same mark, which was the mean between the actual merits of the two? For my part, I was associated with a comrade full of intelligence, but who had not studied this branch of the course. We agreed that he should leave the answering to me, and we found the arrangement advantageous to both.

As I have been led to speak of the school as it was in 1804, I will say that its faults were less those of organization than those of personal management; for many of the professors were much below their office, a fact which gave rise to somewhat ridiculous scenes. The pupils, for instance, having observed the insufficiency of M. Hassenfratz, made a demonstration of the dimensions of the rainbow, full of errors of calculation, but in which the one compensated the other so that the final

result was true. The professor, who had only this result whereby to judge of the goodness of the answer, when he saw it appear on the board, did not hesitate to call out, "Good, good, perfectly good!" which excited shouts of laughter on all the benches of the amphitheater.

When a professor has lost consideration, without which it is impossible for him to do well, they allow themselves to insult him to an incredible extent. Of this I will cite a single specimen.

A pupil, M. Leboullenger, met one evening in company this same M Hassenfratz, and had a discussion with him. When he reëntered the school in the morning, he mentioned this circumstance to us. "Be on your guard," said one of our comrades to him; "you will be interrogated this evening. Play with caution, for the professor has certainly prepared some great difficulties so as to cause laughter at your expense."

Our anticipations were not mistaken. Scarcely had the pupils arrived in the amphitheater, when M. Hassenfratz called to M. Leboullenger, who came to the board.

"M. Leboullenger," said the professor to him, "you have seen the moon?" "No, sir." "How, sir! you say that you have never seen the moon?" "I can only repeat my answer—no, sir." Beside himself, and seeing his prey escape him, by means of this unexpected answer, M. Hassenfratz addressed himself to the inspector charged with the observance of order that day, and said to him, "Sir, there is M. Leboullenger, who pretends never to have seen the moon." "What would you wish me to do?" stoically replied M. Le Brun. Repulsed on this side, the professor turned once more toward M. Leboullenger, who remained calm and earnest in the midst of the unspeakable amusement of the whole amphitheater, and cried out with undisguised anger, "You persist in maintaining that you have never seen the moon?" "Sir," returned the pupil, "I should deceive you if I told you that I had not heard it spoken of, but I have never seen it." "Sir, return to your place."

After this scene, M. Hassenfratz was but a professor in name; his teaching could not longer be of any use.

At the commencement of the second year I was appointed "*chef de brigade.*" Hatchette had been professor of hydrography at Collioure; his friends from Roussillon recommended me to him. He received me with great kindness, and even gave me a room in his lodgings. It was there that I had the pleasure of making Poisson's acquaintance, who lived next to us. Every evening the great geometer entered my room, and we passed entire hours in conversing on politics and mathematics, which is certainly not quite the same thing.

In the course of 1804 the school was a prey to political passions, and that through the fault of the government.

They wished forthwith to oblige the pupils to sign an address of congratulation on the discovery of the conspiracy in which Moreau was implicated. They refused to do so on the ground that it was not for them to pronounce on a cause which had been in the hands of justice.

It must, however, be remarked, that Moreau had not yet dishonored himself by taking service in the Russian army, which had come to attack the French under the walls of Dresden.

The pupils were invited to make a manifestation in favor of the institution of the Legion of Honor. This again they refused. They knew well that the cross, given without inquiry and without control, would be, in most cases, the recompense of charlatanism, and not of true merit.

The transformation of the consular into the imperial government gave rise to very animated discussions in the interior of the school.

Many pupils refused to add their felicitations to the mean adulations of the constituted bodies.

General Lacuée, who was appointed governor of the school, reported this opposition to the Emperor.

"M. Lacuée," cried Napoleon, in the midst of a group of courtiers, who applauded with speech and gesture, "you cannot retain at the school those pupils who have shown such ardent republicanism; you will send them away." Then, collecting himself, he added, "I will first know their names and their stages of promotion." Seeing the list the next day, he did not proceed further than the first name, which was the first in the artillery. "I will not drive away the first men in advancement," said he. "Ah! if they had been at the bottom of the list! M. Lacuée, leave them alone."

Nothing was more curious than the *séance* to which General Lacuée came to receive the oath of obedience from the pupils. In the vast amphitheater which contained them, one could not discern a trace of the gravity which such a ceremony should inspire. The greater part, instead of answering, at the call of their names, "I swear it," cried out, "Present."

All at once, the monotony of this scene was interrupted by a pupil, son of the Conventionalist Brissot, who called out in a stentorian voice, "I will not take the oath of obedience to the Emperor." Lacuée, pale, and with little presence of mind, ordered a detachment of armed pupils placed behind him to go and arrest the recusant. The detachment, of which I was at the head, refused to obey. Brissot, addressing himself to the General, with the greatest calmness said to him, "Point out the place to which you wish me to go; do not force the pupils to dishonor themselves by laying hands on a comrade who has no desire to resist."

The next morning Brissot was expelled.

About this time, M. Méchain, who had been sent to Spain to prolong the meridional line as far as Formentera, died at Castellon de la Plana. His son, secretary at the observatory, immediately gave in his resignation. Poisson offered me the situation. I declined his first proposal. I did not wish to renounce the military career, the object of all my predilections, and in which, morever, I was assured of the protection of

Marshal Lannes, a friend of my father's. Nevertheless I accepted, on trial, the position offered me in the observatory, after a visit which I made to M. de Laplace in company with M. Poisson, under the express condition that I could reënter the artillery if that should suit me. It was from this cause that my name remained inscribed on the list of the pupils of the school. I was only detached to the observatory on a special service.

I entered this establishment, then, on the nomination of Poisson, my friend, and through the intervention of Laplace. The latter loaded me with civilities. I was happy and proud when I dined in the Rue de Tournon with the great geometer. My mind and my heart were much disposed to admire all, to respect all, that was connected with him who had discovered the cause of the secular equation of the moon, had found in the movement of this planet the means of calculating the ellipticity of the earth, had traced to the laws of attraction the long inequalities of Jupiter and of Saturn, &c., &c. But what was my disenchantment when one day I heard Madame de Laplace, approaching her husband, say to him, "Will you intrust to me the key of the sugar."

Some days afterward, a second incident affected me still more vividly. M. de Laplace's son was preparing for the examinations of the Polytechnic School. He came sometimes to see me at the observatory. In one of his visits I explained to him the method of continued fractions, by help of which Lagrange obtains the roots of numerical equations. The young man spoke of it to his father with admiration. I shall never forget the rage which followed the words of Emile de Laplace, and the severity of the reproaches which were addressed to me, for having patronized a mode of proceeding which may be very long in theory, but which evidently can in no way be found fault with on the score of its elegance and precision. Never had a jealous prejudice shown itself more openly, or under a more bitter form. "Ah!" said I to myself, "how true was the inspiration of the ancients when they attributed weaknesses to him who nevertheless made Olympus tremble by a frown."

Here I should mention, in order of time, a circumstance which might have produced the most fatal consequences for me. The fact was this:

I have described above, the scene which caused the expulsion of Brissot's son from the Polytechnic School. I had entirely lost sight of him for several months, when he came to pay me a visit at the obser vatory, and placed me in the most delicate, the most terrible position that an honest man ever found himself in.

"I have not seen you," he said to me, "because since leaving the school I have practiced daily firing with a pistol; I have now acquired a skill beyond the common, and I am about to employ it in ridding France of the tyrant who has confiscated all her liberties. My measures are taken; I have hired a small room on the Carrousel, close to the place by which Napoleon, on coming out from the court, will pass to

review the cavalry; from the humble window of my apartment will the ball be fired which will go through his head."

I leave it to be imagined with what despair I received this confidence. I made every imaginable effort to deter Brissot from his sinister project: I remarked how all those who had rushed on enterprises of this nature had been branded in history by the odious title of assassin. Nothing succeeded in shaking his fatal resolution; I only obtained from him a promise on his honor that the execution of it should be postponed for a time, and I put myself in quest of means for rendering it abortive.

The idea of announcing Brissot's project to the authorities did not even enter my thoughts. It seemed a fatality which came to smite me, and of which I must undergo the consequences, however serious they might be.

I counted much on the solicitations of Brissot's mother, already so cruelly tried during the revolution. I went to her home, in the Rue de Condé, and implored her earnestly to coöperate with me in preventing her son from carrying out his sanguinary resolution. "Ah, sir," replied this lady, who was naturally a model of gentleness, "if Silvain" (this was the name of her son) "believes that he is accomplishing a patriotic duty, I have neither the intention nor the desire to turn him from his project."

It was from myself that I must henceforth draw all my resources. I had remarked that Brissot was addicted to the composition of romances and pieces of poetry. I encouraged this passion, and every Sunday, above all, when I knew that there would be a review, I went to fetch him, and drew him into the country, in the environs of Paris. I listened then complacently to the reading of those chapters of his romance which he had composed during the week.

The first excursions frightened me a little, for, armed with his pistols, Brissot seized every occasion of showing his great skill; and I reflected that this circumstance would lead to my being considered as his accomplice, if he ever carried out his project. At last, his pretensions to literary fame, which I flattered to the utmost, the hopes (though I had none myself) which I led him to conceive of the success of an attachment of which he had confided the secret to me, made him receive with attention the reflections which I constantly made to him on his enterprise. He determined on making a journey beyond the seas, and thus relieved me from the most serious anxiety which I have experienced in all my life.

Brissot died after having covered the walls of Paris with printed handbills in favor of the Bourbon restoration.

I had scarcely entered the observatory, when I became the fellow-laborer of Biot in researches on the refraction of gases, already commenced by Borda.

While engaged in this work the celebrated academician and I often conversed on the interest there would be in resuming in Spain the

measurement interrupted by the death of Méchain. We submitted our project to Laplace, who received it with ardor, procured the necessary funds, and the government confided to us two this important mission.

M. Biot, I, and the Spanish commissary Rodriguez departed from Paris in the commencement of 1806. We visited, on our way, the stations indicated by Méchain, we made some important modifications in the projected triangulation, and at once commenced operations.

An inaccurate direction given to the reflectors established at Iviza, on the mountain Campvey, rendered the observations made on the continent extremely difficult. The light of the signal of Campvey was very rarely seen, and I was, during six months, in the *Desierto de las Palmas*, without being able to see it, while at a later period the light established at the Desierto, but well directed, was seen every evening from Campvey. It will easily be imagined what must be the *ennui* experienced by a young and active astronomer, confined to an elevated peak, having for his walk only a space of twenty square meters, and for diversion only the conversation of two Carthusians, whose convent was situated at the foot of the mountain, and who came in secret, infringing the rule of their order.

At the time when I write these lines, old and infirm, my legs scarcely able to sustain me, my thoughts revert involuntarily to that epoch of my life when, young and vigorous, I bore the greatest fatigues, and walked day and night, in the mountainous countries which separate the kingdoms of Valencia and Catalonia from the kingdom of Aragon, in order to reëstablish our geodesic signals which the storms had overset.

I was at Valencia toward the middle of October, 1806. One morning early the French consul entered my room quite alarmed: "Here is sad news," said M. Lanusse to me; "make preparations for your departure; the whole town is in agitation; a declaration of war against France has just been published; it appears that we have experienced a great disaster in Prussia. The Queen, we are assured, has put herself at the head of the cavalry and of the royal guard; a part of the French army has been cut to pieces; the rest is completely routed. Our lives would not be in safety if we remained here; the French ambassador at Madrid will inform me as soon as an American vessel now at anchor in the 'Grao' of Valencia can take us on board, and I will let you know as soon as the moment is come." This moment never came; for a few days afterward the false news, which one must suppose had dictated the proclamation of the Prince of the Peace, was replaced by the bulletin of the battle of Jéna. People who at first played the braggart and threatened to root us out suddenly became disgracefully cast down; we could walk in the town, holding up our heads, without fear henceforth of being insulted.

This proclamation, in which they spoke of the critical circumstances in which the Spanish nation was placed; of the difficulties which encompassed this people; of the safety of their native country; of laurels,

and of the god of victory; of enemies with whom they ought to fight—did not contain the name of France. They availed themselves of this omission (will it be believed?) to maintain that it was directed against Portugal.

Napoleon pretended to believe in this absurd interpretation; but from this moment it became evident that Spain would sooner or later be obliged to render a strict account of the warlike intentions which she had suddenly evinced in 1806; this, without justifying the events of Bayonne, explains them in a very natural way.

I was expecting M. Biot at Valencia, he having undertaken to bring some new instruments with which we were to measure the latitude of Formentera. I shall take advantage of these short intervals of repose to insert here some details of manners, which may, perhaps, be read with interest.

I will recount, in the first instance, an adventure which nearly cost me my life under somewhat singular circumstances:

One day, as a recreation, I thought I could go, with a fellow-countryman, to the fair at Murviedro, the ancient Saguntum, which they told me was very curious. I met in the town the daughter of a Frenchman resident at Valencia, Mdlle. B——. All the hotels were crowded; Mdlle. B—— invited us to take some refreshments at her grandmother's; we accepted; but on leaving the house she informed us that our visit had not been to the taste of her betrothed, and that we must be prepared for some sort of attack on his part; we went directly to an armorer's, bought some pistols, and commenced our return to Valencia.

On our way I said to the calezero, (driver,) a man whom I had employed for a long time, and who was much devoted to me:

"Isidro, I have some reason to believe that we shall be stopped; I warn you of it, so that you may not be surprised at the shots which will be fired from the caleza," (vehicle.)

Isidro, seated on the shaft, according to the custom of the country, answered:

"Your pistols are completely useless, gentlemen; leave me to act; one cry will be enough; my mule will rid us of two, three, or even four men."

Scarcely one minute had elapsed after the calezero had uttered these words, when two men presented themselves before the mule and seized her by the nostrils. At the same instant a formidable cry, which will never be effaced from my remembrance—the cry of *Capitana!*—was uttered by Isidro. The mule reared up almost vertically, raising up one of the men, came down again, and set off at a rapid gallop. The jolt which the carriage made led us to understand too well what had just occurred. A long silence succeeded this incident; it was only interrupted by these words of the calezero, "Do you not think, gentlemen, that my mule is worth more than any pistols?"

The next day the Captain General, Don Domingo Izquierdo, related

to me that a man had been found crushed on the road to Murviedro. I gave him an account of the prowess of Isidro's mule, and no more was said.

One anecdote, taken from among a thousand, will show what an adventurous life was led by the delegate of the Bureau of Longitude.

During my stay on a mountain near Cullera, to the north of the mouth of the river Xucar, and to the south of the Albuféra, I once conceived the project of establishing a station on the high mountains which are in front of it. I went to see them. The alcaid of one of the neighboring villages warned me of the danger to which I was about to expose myself. "These mountains," said he to me, "form the resort of a band of highway robbers." I asked for the national guard, as I had the power to do so. My escort was supposed by the robbers to be an expedition directed against them, and they dispersed themselves at once over the rich plain which is watered by the Xucar. On my return I found them engaged in combat with the authorities of Cullera. Wounds had been given on both sides, and, if I recollect right, one alguazil was left dead on the plain.

The next morning I regained my station. The following night was a horrible one; the rain fell in a deluge. Toward night there was knocking at my cabin door. To the question "Who is there?" the answer was, "A custom-house guard, who asks of you a shelter for some hours." My servant having opened the door to him, I saw a magnificent man enter, armed to the teeth. He laid himself down on the earth, and went to sleep. In the morning, as I was chatting with him at the door of my cabin, his eyes flashed on seeing two persons on the slope of the mountain, the alcaid of Cullera and his principal alguazil, who were coming to pay me a visit. "Sir," cried he, "nothing less than the gratitude which I owe to you, on account of the service which you have rendered to me this night, could prevent my seizing this occasion for ridding myself, by one shot of this carabine, of my most cruel enemy. Adieu, sir!" And he departed, springing from rock to rock as light as a gazelle.

On reaching the cabin, the alcaid and his alguazil recognized in the fugitive the chief of all the brigands in the country.

Some days afterward, the weather having again become very bad, I received a second visit from the pretended custom-house guard, who went soundly to sleep in my cabin. I saw that my servant, an old soldier, who had heard the recital of the deeds and behavior of this man, was preparing to kill him. I jumped down from my camp bed, and, seizing my servant by the throat, "Are you mad?" said I to him; "are we to discharge the duties of police in this country? Do you not see, moreover, that this would expose us to the resentment of all those who obey the orders of this redoubted chief? and we should thus render it impossible for us to terminate our operations."

Next morning, when the sun rose, I had a conversation with my guest, which I will try to reproduce faithfully.

"Your situation is perfectly known to me; I know that you are not a custom-house guard; I have learned from certain information that you are the chief of the robbers of the country. Tell me whether I have anything to fear from your confederates."

"The idea of robbing you did occur to us, but we concluded that all your funds would be in the neighboring towns; that you would carry no money to the summit of mountains, where you would not know what to do with it, and that our expedition against you could have no fruitful result. Moreover, we cannot pretend to be as strong as the King of Spain. The King's troops leave us quietly enough to exercise our industry, but on the day that we molested an envoy from the Emperor of the French, they would direct against us several regiments, and we should soon have to succumb. Allow me to add, that the gratitude which I owe to you is your surest guarantee."

"Very well, I will trust in your words; I shall regulate my conduct by your answer. Tell me if I can travel at night; it is fatiguing to me to move from one station to another in the day under the burning influence of the sun."

"You can do so, sir; I have already given my orders to this purpose; they will not be infringed."

Some days afterward I left for Denia; it was midnight, when some horsemen rode up to me, and addressed these words to me:

"Stop there, señor; times are hard; those who have something must aid those who have nothing. Give us the keys of your trunks; we will only take your superfluities."

I had already obeyed their orders, when it came into my head to call out, "But I have been told that I could travel without risk."

"What is your name, sir?"

"Don Francisco Arago."

"*Hombre! vaya usted con Dios,*" (God be with you.)

And our cavaliers, spurring away from us, rapidly lost themselves in a field of "algarrobas."

When *my friend* the robber of Cullera assured me that I had nothing to fear from his subordinates, he informed me at the same time that his authority did not extend north of Valencia. The banditti of the northern part of the kingdom obeyed other chiefs, one of whom, after having been taken, was condemned and hung, and his body divided into four quarters, which were fastened to posts on four royal roads, but not without their having previously been boiled in oil, to make sure of their longer preservation.

This barbarous custom produced no effect, for scarcely was one chief destroyed before another presented himself to replace him.

Of all these brigands those had the worst reputation who carried on their depredations in the environs of Oropeza. The proprietors of the three mules on which M. Rodriguez, I, and my servant were riding one evening in this neighborhood were recounting to us the "grand deeds"

of these robbers, which, even in full daylight, would have made the hair of one's head stand on end, when, by the faint light of the moon, we perceived a man hiding himself behind a tree. We were six, and yet this sentry on horseback had the audacity to demand our purses or our lives. My servant at once answered him, "You must then believe us to be very cowardly; take yourself off, or I will bring you down by one shot of my carabine." "I will be off," returned the worthless fellow, "but you will soon hear news of me." Still full of fright at the remembrance of the stories which they had just been relating, the three "arieros" besought us to quit the high road and cast ourselves into a wood which was on our left. We yielded to their proposal, but we lost our way. "Dismount," said they, "the mules have been obeying the bridle, and you have directed them wrongly. Let us retrace our way as far as the high road and leave the mules to themselves; they will well know how to find their right way again." Scarcely had we effected this maneuver, which succeeded marvellously well, when we heard a lively discussion taking place at a short distance from us. Some were saying, "We must follow the high road, and we shall meet with them." Others maintained that they must get into the wood on the left. The barking of the dogs, by which these individuals were accompanied, added to the tumult. During this time we pursued our way silently, more dead than alive. It was two o'clock in the morning. All at once we saw a faint light in a solitary house; it was like a light-house for the mariner in the midst of the tempest, and the only means of safety which remained to us. Arrived at the door of the farm, we knocked and asked for hospitality. The inmates, very little reassured, feared that we were thieves, and did not hurry themselves to open to us.

Impatient at the delay, I cried out, as I had received authority to do so, "In the name of the King, open to us." They obeyed an order thus given; we entered pell-mell, and in the greatest haste, men and mules into the kitchen, which was on the ground floor; and we hurried to extinguish the lights, in order not to awaken the suspicions of the bandits who were seeking for us. Indeed, we heard them, passing and repassing near the house, vociferating with the whole force of their lungs against their unlucky fate. We did not quit this solitary house until broad day, and we continued our route for Tortosa, not without having given a suitable recompense to our hosts. I wished to know by what providential circumstance they happened to have a lamp burning at that unseasonable hour. "We had killed a pig," they told me, "in the course of the day, and we were busy preparing the black puddings." Had the pig lived one day more, or had there been no black puddings, I should certainly have been no longer in this world, and I should not have the opportunity to relate the story of the robbers of Oropeza.

Never could I better appreciate the intelligent measure by which the constituent assembly abolished the ancient division of France into provinces, and substituted its division into departments, than in traversing

for my triangulation the Spanish border kingdoms of Catalonia, Valencia, and Aragon. The inhabitants of these three provinces detested each other cordially, and nothing less than the bond of a common hatred was necessary to make them act simultaneously against France. Such was their animosity in 1807 that I could scarcely make use at the same time of Catalonians, Aragons, and Valencians, when I moved with my instruments from one station to another. The Valencians in particular were treated by the Catalonians as a light, trifling, inconsistent people. They were in the habit of saying to me, "*En el reino de Valencia la carne es verdura, la verdura agua, los hombres mugeres, las mugeres nada,*" which may be translated thus: "In the kingdom of Valencia meat is a vegetable, vegetables are water, men are women, and women nothing."

On the other hand, the Valencians, speaking of the Aragons, used to call them "*schuros.*"

Having asked of a herdsman of this province who had brought some goats near to one of my stations what was the origin of this denomination, at which his compatriots showed themselves so offended:

"I do not know," said he, smiling cunningly at me, "whether I dare answer you." "Go on, go on," I said to him, "I can hear anything without being angry." "Well, the word *schuros* means that, to our great shame, we have sometimes been governed by French kings. The sovereign, before assuming power, was bound to promise under oath to respect our freedom, and to articulate in a loud voice the solemn words *lo Juro!* As he did not know how to pronounce the J, he said *schuro.* Are you satisfied, señor?" I answered him, "Yes, yes; I see that vanity and pride are not dead in this country."

Since I have just spoken of a shepherd, I will say that in Spain the class of individuals of both sexes destined to look after herds appeared to me always less further removed than in France from the pictures which the ancient poets have left us of the shepherds and shepherdesses in their pastoral poetry. The songs by which they endeavor to while away the tedium of their monotonous life are more remarkable in their form and substance than in the other European nations to which I have had access. I never recollect without surprise that, being on a mountain situated at the junction-point of the kingdoms of Valencia, Aragon, and Catalonia, I was all at once overtaken by a violent storm, which forced me to take refuge in my tent, and to remain there squatting on the ground. When the storm was over and I came out from my retreat, I heard, to my great astonishment, on an isolated peak which looked down upon my station, a shepherdess, who was singing a song, of which I only recollect these eight lines, which will give an idea of the rest:

* * * * *
A los que amor no saben
Ofreces las dulzuras
Y a mi las amarguras
Que s'e lo que es amar.

Las gracias al me certe
Eran cuadro de flores
Te cantaban amorese
Por hacerte callar.

Oh! how much sap there is in this Spanish nation! What a pity ıat they will not make it yield fruit?

In 1807, the tribunal of the Inquisition existed still at Valencia, and t times performed its functions. The reverend fathers, it is true, did ot burn people, but they pronounced sentences in which the ridiculous ntended with the odious. During my residence in this town, the oly office had to busy itself about a pretended sorceress; it doomed er to go through all quarters of the town astride on an ass, her face ırned toward the tail, and naked down to the waist. Merely to observe the commonest rules of decency, the poor woman had been plastered with a sticky substance, partly honey, they told me, to which dhered an enormous quantity of little feathers, so that, to say the ruth, the victim resembled a fowl with a human head. The procession, whether attended by a crowd I leave it to be imagined, stationed itself for some time in the cathedral square, where I lived. I was old that the sorceress was struck on the back a certain number of blows with a shovel; but I do not venture to affirm this, for I was absent at the moment when this hideous procession passed before my windows.

We thus see, however, what sort of spectacles were given to the people in the commencement of the nineteenth century, in one of the principal towns of Spain, the seat of a celebrated university, and the native country of numerous citizens distinguished by their knowledge, their courage, and their virtues. Let not the friends of humanity and of civilization disunite; let them form, on the contrary, an indissoluble union, for superstition is always on the watch, and waits for the moment again to seize its prey.

I have mentioned in the course of my narrative that two Carthusians often left their convent in the *Desierto de las Palmas*, and came though prohibited, to see me at my station, situated about two hundred meters higher. A few particulars will give an idea of what certain monks were, in the Peninsula, in 1807.

One of them, Father Trivulce, was old; the other was very young. The former, of French origin, had played a part at Marseilles, in the counter-revolutionary events of which this town was the theater, at the commencement of our first revolution. His part had been a very active one; one might see the proof of this in the scars of saber cuts which furrowed his breast. It was he who was the first to come. When he saw his young comrade march up, he hid himself; but as soon as the latter had fully entered into conversation with me, Father Trivulce showed himself all at once. His appearance had the effect of Medusa's head. "Reassure yourself," said he to his young compeer; "only let us not denounce each other, for our prior is not a man to pardon us for

having come here and infringed our vow of silence, and we should both receive a punishment, the recollection of which would long remain." The treaty was at once concluded, and from that day forward the two Carthusians came very often to converse with me.

The youngest of our two visitors was an Aragonian; his family had made him a monk against his will. He related to me one day, before M. Biot, (then returned from Tarragon, where he had taken refuge to get cured of his fever,) some particulars which, according to him, proved that in Spain there was no longer more than the ghost of religion. These details were mostly borrowed from the secrets of confession. M. Biot manifested sharply the displeasure which this conversation caused him; there were even in his language some words which led the monk to suppose that M. Biot took him for a kind of spy. As soon as this suspicion had entered his mind, he quitted us without saying a word, and the next morning I saw him come up early, armed with a light gun. The French monk had preceded him, and had whispered in my ear the danger that threatened my companion. "Join with me," he said, "to turn the young Aragonian monk from his murderous project." I need scarcely say that I employed myself with ardor in this negotiation, in which I had the happiness to succeed. There were here, as must be seen, the materials for a chief of *guerilleros*. I should be much astonished if my young monk did not play his part in the war of independence.

The anecdote which I am about to relate will amply prove that religion was, with the Carthusian monks of the *Desierto de las Palmas*, not the consequence of elevated sentiments, but a mere compound of superstitious practices.

The scene with the gun, always present to my mind, seemed to make it clear to me that the Aragon monk, if actuated by his passions, would be capable of the most criminal actions. Hence, I had a very disagreeable impression when one Sunday, having come down to hear mass, I met this monk, who, without saying a word, conducted me by a series of dark corridors into a chapel where the daylight penetrated only by a very small window. There I found Father Trivulce, who prepared himself to say mass for me alone. The young monk assisted. All at once, an instant before the consecration, Father Trivulce, turning toward me, said these exact words: "We have permission to say mass with white wine; we therefore make use of that which we gather from our own vines; this wine is very good. Ask the prior to let you taste it, when on leaving this you go to breakfast with him. For the rest, you can assure yourself this instant of the truth of what I say to you." And he presented me the goblet to drink from. I resisted strongly, not only because I considered it indecent to give this invitation in the middle of the mass, but because, besides, I must own I conceived the thought for a moment that the monks wished, by poisoning me, to revenge themselves on me for M. Biot having insulted them. I found that I was

mistaken, that my suspicions had no foundation; for Father Trivulce went on with the interrupted mass, drank, and drank largely, of the white wine contained in one of the goblets. But when I had got out of the hands of the two monks, and was able to breathe the pure air of the country, I experienced a lively satisfaction.

The right of asylum accorded to some churches was one of the most obnoxious privileges among those of which the revolution of 1798 rid France. In 1807, this right still existed in Spain, and belonged, I believe, to all the cathedrals. I learned, during my stay at Barcelona, that there was, in a little cloister contiguous to the largest church of the town, a brigand—a man guilty of several assassinations, who lived quietly there, guaranteed against all pursuit by the sanctity of the place. I wished to assure myself with my own eyes of the reality of the fact, and I went with my friend Rodriguez into the little cloister in question. The assassin was then eating a meal which a woman had just brought him. He easily guessed the object of our visit, and made immediately such demonstrations as convinced us that, if the asylum was safe for the robber, it would not be so long for us. We retired at once, deploring that in a country calling itself civilized there should still exist such crying, such monstrous abuses.

In order to succeed in our geodesic operations, to obtain the coöperation of the inhabitants of the villages near our stations, it was desirable for us to be recommended to the priests. We went, therefore—M. Lanusse, the French vice-consul, M. Biot, and I—to pay a visit to the Archbishop of Valencia, to solicit his protection. This archbishop, a man of very tall figure, was then chief of the Franciscans; his costume, more than negligent, his grey robe, covered with tobacco, contrasted with the magnificence of the archiepiscopal palace. He received us with kindness, and promised us all the recommendations we desired; but, at the moment of taking leave of him, the whole affair seemed to be spoiled. M. Lanusse and M. Biot went out of the reception-room without kissing the hand of his grace, although he had presented it to each of them very graciously. The archbishop indemnified himself on my poor person. A movement, which was very near breaking my teeth, a gesture which I might justly call a blow of the fist, proved to me that the chief of the Franciscans, notwithstanding his vow of humility, had taken offense at the want of ceremony in my fellow-visitors. I was going to complain of the abrupt way in which he had treated me, but I had the necessities of our trigonometrical operations before my eyes, and I was silent.

Besides this, at the instant when the closed fist of the archbishop was applied to my lips, I was still thinking of the beautiful optical experiments which it would have been possible to make with the magnificent stone which ornamented his pastoral ring. This idea, I must frankly declare, had preoccupied me during the whole of the visit.

M. Biot having at last come to seek me again at Valencia, where I ex-

pected, as I have before said, some new instruments, we went on to Formentera, the southern extremity of our arc, of which place we determined the latitude. M. Biot quitted me afterward to return to Paris, while I made the geodesical junction of the island of Majorca to Iviza, and to Formentera, obtaining thus, by means of one single triangle, the measure of an arc of parallel of one degree and a half.

I then went to Majorca, to measure there the latitude and the azimuth. At this epoch, the political fermentation, engendered by the entrance of the French into Spain, began to invade the whole Peninsula and the islands dependent on it. This ferment had as yet in Majorca only reached to the ministers, the partisans, and the relations of the Prince of Peace. Each evening I saw, drawn in triumph in the square of Palma, the capital of the island of Majorca, on carriages, the effigies in flames, sometimes of the minister Soller, another time those of the bishop, and even those of private individuals supposed to be attached to the fortunes of the favorite Godoï. I was far from suspecting then that my turn would soon arrive.

My station at Majorca, the *Clop de Galazo*, a very high mountain, was situated exactly over the port where *Don Jayme el Conquistator* disembarked when he went to deliver the Balearic Islands from the Moors. The report spread itself through the population that I had established myself there in order to favor the arrival of the French army, and that every evening I made signals to it. But these reports had nothing menacing until the moment of the arrival at Palma, the 27th of May, 1808, of an ordnance officer from Napoleon. This officer was M. Berthémie; he carried to the Spanish squadron, at Mahon, the order to go in all haste to Toulon. A general rising, which placed the life of this officer in danger, followed the news of his mission. The Captain General Vivés only saved his life by shutting him up in the strong castle of Belver. They then bethought themselves of the Frenchman established on the *Clop de Galazo*, and formed a popular expedition to go and seize him.

M. Damian, the owner of a small kind of vessel called a mistic, which the Spanish government had placed at my disposal, was beforehand with them, and brought me a costume by means of which I disguised myself. In directing myself toward Palma, in company with this brave seaman, we met with the rioters, who were going in search of me. They did not recognize me, for I spoke Majorcan perfectly. I strongly encouraged the men of this detachment to continue their route, and I pursued my way toward Palma. At night I went on board the mistic, commanded by Don Manuel de Vacaro, whom the Spanish government had placed under my orders. I asked this officer if he would conduct me to Barcelona, occupied by the French, promising him that, if they made any attempt to keep him there, I would at once return and surrender myself a prisoner.

Don Manuel, who up to this time had shown extreme obsequiousness

toward me, had now no words but those of rudeness and distrust. There occurred on the pier where the mistic was moored a riotous movement, which Vacaro assured me was directed against me. "Do not be uneasy," said he to me; "if they should penetrate into the vessel, you can hide yourself in this trunk." I made the attempt, but the chest which he showed me was so small that my legs were entirely outside, and the cover could not be shut down. I understood perfectly what that meant, and I asked M. Vacaro to let me also be shut up in the castle of Belver. The order for incarceration having arrived from the captain general, I got into the boat, where the sailors of the mistic received me with emotion.

At the moment of their crossing the harbor, the populace perceived me, commenced a pursuit, and it was not without much difficulty that I reached Belver safe and sound. I had only, indeed, received on my way one slight wound from a dagger in the thigh. Prisoners have often been seen to run with all speed *from* their dungeon; I am the first, perhaps, to whom it has happened to do the reverse. This took place on the 1st or 2d of June, 1808.

The governor of Belver was a very extraordinary personage; if he is still alive, he may demand of me a certificate as to his priority to the modern hydropathists. The grenadier captain maintained that pure water, suitably administered, was a means of treatment for all illnesses, even for amputations; by listening very patiently to his theories, and never interrupting him, I won his good opinion. It was at his request, and from interest in our safety, that a Swiss garrison replaced the Spanish troop which, until then, had been employed as the guard of Belver. It was also through him that I one day learned that a monk had proposed to the soldiers who went to bring my food from the town, to put some poison into one of the dishes.

All my old Majorcan friends had abandoned me at the moment of my detention. I had had a very sharp correspondence with Don Manuel de Vacaro, in order to obtain the restitution of the passport of safety which the English admiralty had granted to us. M. Rodriguez alone ventured to visit me in full daylight, and bring me every consolation in his power.

The excellent M. Rodriguez, to while away the monotony of my incarceration, remitted to me, from time to time, the journals which were then published at different parts of the Peninsula. He often sent them to me without reading them. Once I saw in these journals the recital of the horrible massacres of which the town of Valencia—I make a mistake, the *square of the bull-fights*—had been the theater, and in which nearly the whole of the French established in this town (more than three hundred and fifty) had disappeared under the pike of the bull-fighter. Another journal contained an article bearing this title, "Relacion de la ahorcadura del Señor Arago e del Señor Berthémie"—literally, "Account of the Execution of M. Arago and M. Berthémie."

This account spoke of the two executed men in very different terms. M. Berthémie was a Huguenot; he had been deaf to all exhortations; he had spit in the face of the ecclesiastic who was present, and even on the image of Christ. As for me, I had conducted myself with much decency, and had allowed myself to be hung without giving rise to any scandal. The writer also expressed his regret that a young astronomer had been so weak as to associate himself with treason, coming under the disguise of science to assist the entrance of the French army into a friendly kingdom.

After reading this article, I immediately made my decision. "Since they talk of my death," said I to my friend Rodriguez, "the event will not be long in coming; I should prefer being drowned to being hung. I will make my escape from this fortress; it is for you to furnish me with the means."

Rodriguez, knowing better than any one how well founded my apprehensions were, set himself at once to the work. He went to the captain general, and made him feel what would be the danger of his position if I should disappear in a popular riot, or even if he were forced to give me up. His observations were so much the better comprehended, as no one could then predict what might be the issue of the Spanish revolution. "I will undertake," said the captain general Vivés to my colleague Rodriguez, "to give an order to the commander of the fortress, that when the right moment arrives, he shall allow M. Arago, and even the two or three other Frenchmen who are with him in the castle of Belver, to pass out; they will then have no need of the means of escape which they have procured. But I will take no part in the preparations which will become necessary to enable the fugitives to leave the island; I leave all that to your responsibility."

Rodriguez immediately conferred secretly with the brave commander Damian. It was agreed between them that Damian should take the command of a half-decked boat which the wind had driven ashore; that he should equip it as if for a fishing expedition; that he should carry us to Algiers, after which his reëntrance at Palmas, with or without fish, would inspire no suspicion. All was executed according to agreement, notwithstanding the inquisitorial surveillance which Don Manuel de Vacaro exercised over the commander of his "mistic."

On the 28th July, 1808, we silently descended the hill on which Belver is built, at the same moment that the family of the minister Soller entered the fortress to escape the fury of the populace. Arrived at the shore, we found there Damian, his boat, and three sailors; we embarked at once, and set sail. Damian had taken the precaution of bringing with us in this frail vessel the instruments of value which he had carried off from my station at the *Clop de Galazo*. The sea was unfavorable; Damian thought it prudent to stop at the little island of Cabrera, destined to become, a short time afterward, so sadly celebrated by the sufferings which the soldiers of the army of Dupont experienced after

the shameful capitulation of Baylen. There a singular incident was very near compromising all: Cabrera, tolerably near to the southern extremity of Majorca, is often visited by fishermen coming from that part of the island. M. Berthémie feared, justly enough, that, the rumor of our escape having spread about, they might dispatch some boats to seize us. He looked upon our going into harbor as inopportune; I maintained that we must yield to the prudence of the commander. During this discussion, the three seamen whom Damian had engaged saw that M. Berthémie, whom I had endeavored to pass off as my servant, maintained his opinion against me on a footing of equality. They then addressed themselves in these terms to the commander:

"We only consented to take part in this expedition upon condition that the Emperor's aid-de-camp, shut up at Belver, should not be of the number of those persons whom we should help off; we only wished to aid the flight of the astronomer. Since it seems to be otherwise, you must leave this officer here, unless you would prefer to throw him into the sea."

Damian at once informed me of the imperative wishes of his boat's crew. M. Berthémie agreed with me to suffer some abuse, such as could only be tolerated by a servant threatened by his master: all the suspicions disappeared.

Damian, who feared also for himself the arrival of Majorcan fishermen, hastened to set sail on the 29th of July, 1808, the first moment that was favorable, and we arrived at Algiers on the 3d of August.

Our looks were anxiously directed toward the port, to guess what reception might await us. We were reassured by the sight of the tricolored flag which was flying on two or three buildings; but we were mistaken, these buildings were Dutch. Immediately upon our entrance, a Spaniard, whom, from his tone of authority, we took for a high functionary of the regency, came up to Damian, and asked him, "What do you bring?" "I bring," answered the commander, "four Frenchmen." "You will at once take them back again; I prohibit you from disembarking." As we did not seem inclined to obey his order, our Spaniard, who was the constructing engineer of the ships of the Dey, armed himself with a pole, and commenced battering us with blows; but immediately a Genoese seaman, mounted on a neighboring vessel, armed himself with an oar, and struck our assailant both with edge and point. During this animated combat, we managed to land without any opposition. We had conceived a singular idea of the manner in which the police act on the coast of Africa.

We pursued our way to the French consul's, M. Dubois Thainville; he was at his country house. Escorted by the janissary of the consulate, we went off toward this country house, one of the ancient residences of the Dey, situated not far from the gate of Bab-azoum. The consul and his family received us with great amity, and offered us hospitality.

Suddenly transported to a new continent, I looked forward anxiously

to the rising of the sun to enjoy all that Africa might offer of interest to a European, when all at once I believed myself to be engaged in a serious adventure. By the faint light of the dawn, I saw an animal moving at the foot of my bed. I gave a kick with my foot; all movement ceased. After some time, I felt the same movement under my legs. A sharp jerk made this cease quickly. I then heard the fits of laughter of the janissary, who lay on a couch in the same room as I did; and I soon saw that he had simply placed on my bed a large hedgehog to amuse himself by my uneasiness.

The consul occupied himself the next day in procuring a passage for us on board a vessel of the Regency which was going to Marseilles. M. Ferrier, the chancellor of the French consulate, was at the same time consul for Austria. He procured for us two false passports, which transformed us—M. Berthémie and me—into two strolling merchants, the one from Schwekat, in Hungary, the other from Leoben.

The moment of departure had arrived; the 13th of August, 1808, we were on board, but our ship's company was not complete. The captain, whose title was Raï Braham Ouled Mustapha Goja, having perceived that the Dey was on his terrace, and fearing punishment if he should delay to set sail, completed his crew at the expense of the idlers who were looking on from the pier, and of whom the greater part were not sailors. These poor people begged as a favor for permission to go and inform their families of this precipitate departure, and to get some clothes. The captain remained deaf to their remonstrances. We weighed anchor.

The vessel belonged to the Emir of Seca, director of the mint. The real commander was a Greek captain, named Spiro Calligero. The cargo consisted of a great number of *groups*. Among the passengers there were five members of the family which the Bakri had succeeded as kings of the Jews; two ostrich-feather merchants, Moroccans; Captain Krog, from Berghen in Norway, who had sold his ship at Alicant; two lions sent by the Dey to the Emperor Napoleon, and a great number of monkeys. Our voyage was prosperous. Off Sardinia we met with an American ship coming out from Cagliari. A cannon-shot (we were armed with forty pieces of small power) warned the captain to come to be recognized. He brought on board a certain number of counterparts of passports, one of which agreed perfectly with that which we carried. The captain being thus all right, was not a little astonished when I ordered him, in the name of Captain Braham, to furnish us with tea, coffee, and sugar. The American captain protested; he called us brigands, pirates, robbers. Captain Braham admitted without difficulty all these qualifications, and persisted none the less in the exaction of sugar, coffee, and tea.

The American, then driven to the last stage of exasperation, addressed himself to me, who acted as interpreter, and cried out, "Oh! rogue of a renegade! if ever I meet you on holy ground I will break your head." "Can you then suppose," I answered him, "that I am here for my

pleasure, and that, nothwithstanding your menace, I would not rather go with you, if I could?" These words calmed him; he brought the sugar, the coffee, and the tea claimed by the Moorish chief and we again set sail, though without having exchanged the usual farewell.

We had already entered the Gulf of Lyons, and were approaching Marseilles, when on the 16th August, 1808, we met with a Spanish corsair from Palamos, armed at the prow with two 24-pounders. We made full sail; we hoped to escape it: but a cannon shot, a ball from which went through our sails, taught us that she was a much better sailer than we were.

We obeyed an injunction thus expressed, and awaited the great boat from the corsair. The captain declared that he made us prisoners, although Spain was at peace with Barbary, under the pretext that we were violating the blockade which had been lately raised on all the coasts of France; he added that he intended to take us to Rosas, and that there the authorities would decide on our fate.

I was in the cabin of the vessel; I had the curiosity to look furtively at the crew of the boat, and there I perceived, with a dissatisfaction which may easily be imagined, one of the sailors of the "mistic," commanded by Don Manuel de Vacaro, of the name of Pablo Blanco, of Palamos, who had often acted as my servant during my geodesec operations. My false passport would become from this moment useless, if Pablo should recognize me. I went to bed at once, covered my head with a counterpane,and lay as still as a statue.

During the two days which elapsed between our capture and our entrance into the roads of Rosas, Pablo, whose curiosity often brought him into the room, used to exclaim, "There is one passenger whom I have not yet managed to get a sight of."

When we arrived at Rosas it was decided that we should be placed in quarantine in a dismantled windmill, situated on the road leading to Figueras. I was careful to disembark in a boat to which Pablo did not belong. The corsair departed for a new cruise, and I was for a moment freed from the harassing thoughts which my old servant had caused me.

Our ship was richly laden; the Spanish authorities were immediately desirous to declare it a lawful prize. They pretended to believe that I was the proprietor of it, and wished, in order to hasten things, to interrogate me, even without awaiting the completion of the quarantine. They stretched two cords between the mill and the shore; and a judge placed himself in front of me. As the interrogatories were made from a good distance, the numerous audience which encircled us took a direct part in the questions and answers. I will endeavor to reproduce this dialogue with all possible fidelity:

"Who are you?"

"A poor roving merchant."

"Whence do you come?"

"From a country where you certainly never were."

"In a word, what country is it?"

I was afraid to answer, for the passports, steeped in vinegar, were in the hands of the judge-instructor, and I had forgotten whether I was from Schwekat or from Leoben. Finally I answered at all hazards:

"I come from Schwekat."

And this information happily was found to agree with that of the passport.

"You are as much from Schwekat as I am," answered the judge. "You are Spanish, and, moreover, a Spaniard from the kingdom of Valencia, as I perceive by your accent."

"Would you punish me, sir, because nature has endowed me with the gift of languages? I learn with facility the dialects of those countries through which I pass in the exercise of my trade; I have learned, for example, the dialect of Iviza."

"Very well, you shall be taken at your word. I see here a soldier from Iviza; you shall hold a conversation with him."

"I consent; I will even sing the goat song."

Each of the verses of this song (if verses they be) terminates by an imitation of the bleating of the goat.

I commenced at once, with an audacity at which I really feel astonished, to chant this air, which is sung by all the shepherds of the island:

Ah graciada señora
Una cauzo bouil canta
Bè, bè, bè, bè.
No sera gaira pulida
Nosé si vos agradara
Bè, bè, bè, bè.

At once my Ivizacan, upon whom this air had the effect of the *ranz des vaches* on the Swiss, declared, all in tears, that I was a native of Iviza.

I then said to the judge that if he would put me in communication with a person knowing the French language, he would arrive at just as embarrassing a result. An *émigré* officer of the Bourbon regiment offered at once to make the experiment, and, after some phrases interchanged between us, affirmed without hesitation that I was French.

The judge, rendered impatient, exclaimed, "Let us put an end to these trials which decide nothing. I summon you, sir, to tell me who you are. I promise that your life will be safe if you answer me with sincerity."

"My greatest wish would be to give an answer to your satisfaction. I will, then, try to do so; but I warn you that I am not going to tell you the truth. I am the son of the innkeeper at Mataró." "I know that innkeeper; you are not his son." "You are right. I announced to you that I should vary my answers until one of them should suit you. I retract then, and tell you that I am a *titiretero* (player of marionettes) and that I practiced at Lerida."

A loud shout of laughter from the multitude encircling us greeted this answer, and put an end to the questions.

"I swear by the d——l," exclaimed the judge, "that I will discover sooner or later who you are!"

And he retired.

The Arabs, the Moroccans, the Jews, who witnessed this interrogatory, understood nothing of it; they had only seen that I had not allowed myself to be intimidated. At the close of the interview they came to kiss my hand, and gave me, from this moment, their entire confidence.

I became their secretary for all the individual or collective remonstrances which they thought they had a right to address to the Spanish government; and this right was incontestable. Every day I was occupied in drawing up petitions, especially in the name of the two ostrich-feather merchants, one of whom called himself a tolerably near relation of the Emperor of Morocco. Astonished at the rapidity with which I filled a page of my writing, they imagined, doubtless, that I should write as fast in Arabic characters, when it should be requisite to transcribe passages from the Koran; and that this would form both for me and for them the source of a brilliant fortune, and they besought me, in the most earnest way, to become a Mahomedan.

Very little reassured by the last words of the judge, I sought means of safety from another quarter.

I was the possessor of a safe-conduct from the English admiralty; I therefore wrote a confidential letter to the captain of an English vessel, the "Eagle," I think, which had cast anchor some days before in the roads at Rosas. I explained to him my position. "You can," I said, "claim me, because I have an English passport. If this proceeding should cost you too much, have the goodness at least to take my manuscripts and to send them to the Royal Society in London."

One of the soldiers who guarded us, and in whom I had fortunately inspired some interest, undertook to deliver my letter. The English captain came to see me; his name was, if my memory is right, George Eyre. We had a private conversation on the shore. George Eyre thought perhaps that the manuscripts of my observations were contained in a register bound in morocco, and with gilt edges to the leaves. When he saw that these manuscripts were composed of single leaves covered with figures, which I had hidden under my shirt, disdain succeeded to interest, and he quitted me hastily. Having returned on board he wrote me a letter which I could find if needful, in which he said to me, "I cannot mix myself up in your affairs; address yourself to the Spanish government; I am persuaded that it will do justice to your remonstrance and will not molest you." As I had not the same persuasion as Captain George Eyre, I chose to take no notice of his advice.

I ought to mention that some time after having related these particulars in England at Sir Joseph Banks's, the conduct of George Eyre was

severely blamed; but when a man breakfasts and dines to the sound of harmonious music, can he accord his interest to a poor devil sleeping on straw and nibbled by vermin, even though he have manuscripts under his shirt? I may add that I (unfortunately for me) had to do with a captain of an unusual character. For, some days later, a new vessel, the Colossus, having arrived in the roads, the Norwegian, Captain Krog, although he had not, like me, an admiralty passport, made an application to the commander of this new ship; he was immediately claimed and relieved from captivity.

The report that I was a Spanish deserter and proprietor of the vessel, acquiring more and more credit, and this position being the most dangerous of all, I resolved to get out of it. I begged the commandant of the place, M. Alloy, to come to receive my declaration, and I announced to him that I was French. To prove to him the truth of my words I invited him to send for Pablo Blanco, the sailor in the service of the corsair who took us, and who had returned from his cruise a short time before. This was done as I wished. In disembarking, Pablo Blanco, who had not been warned, exclaimed with surprise, "What! you Don Francisco, mixed up with all these miscreants!" The sailor gave the governor circumstantial evidence as to the mission which I fulfilled with two Spanish commissaries. My nationality thus became proved.

That same day Alloy was replaced in the command of the fortress by the Irish colonel of the Ultonian regiment; the corsair left for a fresh cruise, taking away Pablo Blanco; and I became once more the roving merchant from Schwekat.

From the windmill where we underwent our quarantine, I could see the tricolored flag flying on the fortress of Figueras. The reconnoitering parties of the cavalry came sometimes within five or six hundred meters; it would not then have been difficult for me to escape. However, as the regulations against those who violate the sanitary laws are very rigorous in Spain, as they pronounce the penalty of death against him who infringes them, I only determined to make my escape on the eve of our admission to pratique.

The night being come I crept on all-fours along the briars, and I should soon have got beyond the line of sentinels who guarded us. A noisy uproar which I heard among the Moors made me determine to reënter, and I found these poor people in an unspeakable state of uneasiness, thinking themselves lost if I left; I therefore remained.

The next day a strong picket of troops presented itself before the mill. The maneuvers made by it inspired all of us with anxiety, but especially Captain Krog.* "What will they do with us?" he exclaimed. "Alas! you will see only too soon," replied the Spanish officer. This answer made every one believe that they were going to shoot us. What might have strengthened me in this idea was the obstinacy with which

* This appears to be an oversight, as in a preceding page M. Arago described the *fortunate release* of Captain Krog from this captivity.

Captain Krog and two other individuals of small size hid themselves behind me. A handling of arms made us think that we had but a few seconds to live.

In analyzing the feelings which I experienced on this solemn occasion, I have come to the conclusion that the man who is led to death is not as unhappy as the public imagines him to be. Fifty ideas presented themselves nearly simultaneously to my mind, and I did not rack my brain for any of them; I only recollect the two following which have remained engraved on my memory. On turning my head to the right, I saw the national flag flying on the bastions of Figueras, and I said to myself, 'If I were to move a few hundred meters I should be surrounded by comrades, by friends, by fellow-citizens, who would receive me affectionately. Here, without their being able to impute any crime to me, I am going to suffer death at twenty-two years of age." But what agitated me more deeply was this: looking toward the Pyrenees I could distinctly see their peaks, and I reflected that my mother, on the other side of the chain, might at this awful moment be looking peaceably at them.

The Spanish authorities, finding that to redeem my life I would not declare myself the owner of the vessel, had us conducted without further molestation to the fortress of Rosas. Having to file through nearly all the inhabitants of the town, I had wished at first, through a false feeling of shame, to leave in the mill the remains of our week's meals. But M. Berthémie, more prudent than I, carried over his shoulder a great quantity of pieces of black bread tied up with packthread. I imitated him. I furnished myself famously from our old stock, set it on my shoulder, and it was with this accoutrement that I made my entrance into the famous fortress.

They placed us in a casemate, where we had barely the space necessary for lying down. In the windmill they used to bring us, from time to time, some provisions which came from our boat. Here, the Spanish government purveyed our food. We received every day some bread and a ration of rice; but as we had no means of dressing food, we were in reality reduced to dry bread.

Dry bread was very unsubstantial food for one who could see from his casemate, at the door of his prison, a sutler selling grapes at two farthings a pound, and cooking, under the shelter of half a cask, bacon and herrings; but we had no money to bring us into connection with this merchant. I then decided, though with very great regret, to sell a watch which my father had given me. I was only offered about a quarter of its value; but I might well accept it since there were no competitors for it.

As possessors of sixty francs, M. Berthémie and I could now appease the hunger from which we had long suffered; but we did not like this return of fortune to be profitable to ourselves alone, and we made some presents, which were very well received by our companions in captivity.

Though this sale of my watch brought some comfort to us, it was doomed at a later period to plunge a family into sorrow.

The town of Rosas fell into the power of the French after a courageous resistance. The prisoners of the garrison were sent to France, and naturally passed through Perpignan. My father went in quest of news wherever Spaniards were to be found. He entered a café at the moment when a prisoner officer drew from his fob the watch which I had sold at Rosas. My good father saw in this act the proof of my death, and fell into a swoon. The officer had got the watch from a third party, and could give no account of the fate of the person to whom it had originally belonged.

The casemate having become necessary to the defenders of the fortress, we were taken to a little chapel where they deposited for twenty-four hours those who had died in the hospital. There we were guarded by peasants who had come across the mountain from various villages, and particularly from Cadaquès. These peasants, eager to recount all that they had seen of interest during their one day's campaign, questioned me as to the deeds and behavior of all my companions in misfortune. I satisfied their curiosity amply, being the only one of the set who could speak Spanish.

To enlist their good will, I also questioned them at length upon the subject of their village, on the work that they did there, on smuggling, their principal sources of employment, &c., &c. They answered my questions with the loquacity common to country rustics. The next day our guards were replaced by some others who were inhabitants of the same village. "In my business of a roving merchant," I said to these last, "I have been at Cadaquès;" and then I began to talk to them of what I had learnt the night before of such an individual, who gave himself up to smuggling with more success than others, of his beautiful residence, of the property which he possessed near the village; in short, of a number of particulars which it seemed impossible for any but an inhabitant of Cadaquès to know. My jest produced an unexpected effect. Such circumstantial details, our guards said to themselves, cannot be known by a roving merchant; this personage whom we have found here in such singular society, is certainly a native of Cadaquès; and the son of the apothecary must be about his age. He had gone to try his fortune in America; it is evidently he, who fears to make himself known, having been found with all his riches in a vessel on its way to France. The report spread, became more consistent, and reached the ears of a sister of the apothecary established at Rosas. She runs to me, believes she recognizes me, and falls on my neck. I protest against the identity. "Well played!" said she to me; "the case is serious, as you have been found in a vessel coming to France; persist in your denial; circumstances may perhaps take a more favorable turn, and I shall profit by them to insure your deliverance. In the mean time, my

r nephew, I will let you want for nothing." And truly every morn-
M. Berthémie and I received a comfortable repast.
'he church having become necessary to the garrison to serve as a
gazine, we were moved on the 25th of September, 1808, to a Trinity
, called the *Bouton de Rosas*, a citadel situated on a little mountain
he entrance of the roads, and we were deposited deep under ground,
ere the light of day did not penetrate on any side. We did not long
ain in this infected place; not because they had pity upon us, but
ause it offered shelter for a part of the garrison attacked by the
nch. They made us descend by night to the edge of the sea, and
a transported us on the 17th of October to the port of Palamos.
were shut up in a hulk; we enjoyed, however, a certain degree of
rty; they allowed us to go on land and to parade our miseries and
rags in the town. It was there that I made the acquaintance of the
'ager Duchess of Orleans, mother of Louis Phillippe. She had left
town of Figueras where she resided, because, she told me, thirty-
bombs sent from the fortress had fallen in her house. She was then
nding to take refuge in Algiers, and she asked me to bring the cap-
of the vessel to her, of whom, perhaps, she would have to implore
tection. I related to my "*raïs*" the misfortunes of the princess; he
moved by them, and I conducted him to her. On entering he took
his slippers from respect, as if he had entered within a mosque, and
ling them in his hand, he went to kiss the front of the dress of
lame d'Orleans. The princess was alarmed at the sight of this manly
re, wearing the longest beard I ever saw; she quickly recovered her-
, and the interview proceeded with a mixture of French politeness
oriental courtesy.
he sixty francs from Rosas were expended. Madame d'Orleans
ld have liked much to assist us, but she was herself without money.
that she could gratify us with was a piece of sugar-bread. The
ning of our visit I was richer than the princess. To avoid the fury
he people the Spanish government sent those French who had
ped the first massacres back to France in slight boats. One of the
els came and cast anchor by the side of our hulk. One of the un-
py emigrants offered me a pinch of snuff. On opening the snuff-box
and there "*una onza de oro*," (an ounce of gold,) the sole remains of
fortune. I returned the snuff-box to him, with warm thanks, after
ing shut up in it a paper containing these words: "My fellow-coun-
nan who carries this note has rendered me a great service; treat
as one of your children." My petition was naturally favorably
ived; it was by this bit of paper, the size of the *onza de oro*, that
family learnt that I was still in existence, and it enabled my mother,
odel of piety, to cease saying masses for the repose of my soul.
ive days afterward, one of my hardy compatriots arrived at Pal-
os, after having traversed the line of posts, both French and Spanish,
ying to a merchant who had friends at Perpignan the proposal to

furnish me with all I was in need of. The Spaniard showed a great inclination to agree to the proposal; but I did not profit by his good will, because of the occurrence of events which I shall relate presently.

The observatory at Paris is very near the barrier. In my youth, curious to study the manners of the people, I used to walk in sight of the public houses, which the desire of escaping payment of the duty has multiplied outside the walls of the capital. On these excursions I was often humiliated to see men disputing for a piece of bread, just as animals might have done. My feelings on this subject have very much altered since I have been personally exposed to the tortures of hunger. I have discovered, in fact, that a man, whatever may have been his origin, his education, and his habits, is governed, under certain circumstances, much more by his stomach than by his intelligence and his heart. Here is the fact which suggested these reflections to me:

To celebrate the unhoped-for arrival of *una onza de oro*, M. Berthémie and I had produced an immense dish of potatoes. The ordnance officer of the Emperor was already devouring it with his eyes, when a Moroccan, who was making his ablutions near us with one of his companions, accidentally filled it with dirt. M. Berthémie could not control his anger, he darted upon the clumsy Mussulman, and inflicted upon him a rough punishment.

I remained a passive spectator of the combat, until the second Moroccan came to the aid of his compatriot. The party no longer being equal, I also took part in the conflict, by seizing the new assailant by the beard. The combat ceased at once, because the Moroccan would not raise his hand against a man who could write a petition so rapidly. This conflict, like the struggles of which I had often been a witness outside the barriers of Paris, had originated in a dish of potatoes.

The Spaniards always cherished the idea that the ship and her cargo might be confiscated; a commission came from Girone to question us. It was composed of two civil judges and one inquisitor. I acted as interpreter. When M. Berthémie's turn came, I went to fetch him, and said to him, "Pretend that you can only talk Styrian, and be at ease; I will not compromise you in translating your answers."

It was done as we had agreed; unfortunately the language spoken by M. Berthémie had but little variety, and the *sacrement der Teufel*, which he had learned in Germany, when he was aide-de-camp to Hautpoul, predominated too much in his discourse. Be that as it may, the judges observed that there was too great a conformity between his answers and those which I had made myself to render it necessary to continue an interrogatory, which I may say, by the way, disturbed me much. The wish to terminate it was still more decided on the part of the judges, when it came to the turn of a sailor named Mehemet. Instead of making him swear on the Koran to tell the truth, the judge was determined to make him place his thumb on the fore-finger so as to represent the cross. I warned him that great offense would thus be given; and, accordingly,

When Mehemet became aware of the meaning of this sign, he began to spit upon it with inconceivable violence. The meeting ended at once.

The next day things had wholly changed their appearance; one of the judges from Girone came to declare to us that we were free to depart, and to go with our ship wherever we chose. What was the cause of this sudden change? It was this:

During our quarantine in the windmill at Rosas, I had written, in the name of Captain Braham, a letter to the Dey of Algiers. I gave him an account of the illegal arrest of his vessel, and of the death of one of the lions which the Dey had sent to the Emperor. This last circumstance transported the African monarch with rage. He sent immediately for the Spanish consul, M. Onis, claimed pecuniary damages for his dear lion, and threatened war if his ship was not released directly. Spain had then to do with too many difficulties to undertake wantonly any new ones, and the order to release the vessel so anxiously coveted arrived at Girone, and from thence at Palamos.

This solution, to which our consul at Algiers, M. Dubois Thainville, had not remained inattentive, reached us at the moment when we least expected it. We at once made preparations for our departure, and on the 28th of November, 1808, we set sail, steering for Marseilles; but, as the Mussulmen on board the vessel declared, it was written above that we should not enter that town. We could already perceive the white buildings which crown the neighboring hills of Marseilles, when a gust of the "mistral," of great violence, sent us from the north towards the south.

I do not know what route we followed, for I was lying in my cabin, overcome with sea-sickness; I may, therefore, though an astronomer, avow without shame, that at the moment when our unqualified pilots supposed themselves to be off the Baléares, we landed, on the 5th of December, at Bougie.

There, they pretended that during the three months of winter all communication with Algiers, by means of the little boats named *sandalis*, would be impossible, and I resigned myself to the painful prospect of so long a stay in a place at that time almost a desert. One evening I was making these sad reflections while pacing the deck of the vessel, when a shot from a gun on the coast came and struck the side planks close to which I was passing. This suggested to me the thought of going to Algiers by land.

I went next day, accompanied by M. Berthémie and Captain Spiro Calligero, to the Caïd of the town: "I wish," said I to him, "to go to Algiers by land." The man, quite frightened, exclaimed, "I cannot allow you to do so; you would certainly be killed on the road; your consul would make a complaint to the Dey, and I should have my head cut off."

"Fear not on that ground. I will give you an acquittance."

It was immediately drawn up in these terms:

"We, the undersigned, certify that the Caïd of Bougie wished to dissuade us from going to Algiers by land; that he has assured us that we shall be massacred on the road; that notwithstanding his representations, reiterated twenty times, we have persisted in our project. We beg the Algerine authorities, particularly our consul, not to make him responsible for this event if it should occur. We once more repeat that the voyage has been undertaken against his will.

"ARAGO AND BERTHÉMIE."

Having given this declaration to the Caïd, we considered ourselves quit of this functionary; but he came up to me, undid, without saying a word, the knot of my cravat, took it off, and put it into his pocket. All this was done so quickly that I had not time, I will add that I had not even the wish, to reclaim it.

At the conclusion of this audience, which had terminated in so singular a manner, we made a bargain with a Mahomedan priest, who promised to conduct us to Algiers for the sum of twenty "piastres fortes" and a red mantle. The day was occupied in disguising ourselves, well or ill, and we set out the next morning, accompanied by several Moorish sailors belonging to the crew of the ship, after having shown the Mahomedan priest that we had nothing with us worth a sou, so that if we were killed on the road he would inevitably lose all reward.

I went, at the last moment, to make my bow to the only lion that was still alive, and with whom I had lived in very good harmony; I wished also to say good-bye to the monkeys, who during nearly five months had been equally my companions in misfortune.* These monkeys during our frightful misery had rendered us a service which I scarcely dare mention, and which will scarcely be guessed by the inhabitants of our cities, who look upon these animals as objects of diversion: they freed us from the vermin which infested us, and showed particularly a remarkable cleverness in seeking out the hideous insects which lodged themselves in our hair.

Poor animals! they seem to me very unfortunate in being shut up in the narrow inclosure of the vessel, when, on the neighboring coast, other monkeys, as if to bully them, came on to the branches of the trees, giving innumerable proofs of their agility.

At the commencement of the day, we saw on the road two Kabyls, similar to the soldiers of Jugurtha, whose harsh appearance powerfully allayed our fancy for wandering. In the evening we witnessed a fearful tumult, which appeared to be directed against us. We learnt afterward

* On my return to Paris I hastened to the Jardin des Plantes to pay a visit to the lion, but he received me with a very unamiable gnashing of the teeth. Think, then, of the marvelous history of the Florentine lion, the subject of so many engravings, which is offered on the stall of every print-seller to the eyes of the moved and astonished passers by.

that the Mahomedan priest had been the object of it; that it originated with some Kabyls whom he had disarmed on one of their journeys to Bougie. This incident, which appeared likely to be repeated, inspired us for a moment with the thought of returning; but the sailors were resolute, and we continued our hazardous enterprise.

In proportion as we advanced, our troops became increased by a certain number of Kabyls, who wished to go to Algiers to work there in the quality of seamen, and who dared not undertake alone this dangerous journey.

The third day we encamped in the open air, at the entrance of a forest. The Arabs lighted a very large fire in the form of a circle, and placed themselves in the middle. Toward eleven o'clock I was awakened by the noise which the mules made, all trying to break their fastenings. I asked what was the cause of this disturbance. They answered me that a "*sebâá*" had come roaming in the neighborhood. I was not aware then that a "*sebâá*" was a lion, and I went to sleep again. The next day, in traversing the forest, the arrangement of the caravan was changed. It was grouped in the smallest space possible; one Kabyl was at the head, his gun ready for service; another was in the rear, in the same position. I inquired of the owner of the mule the cause of these unusual precautions. He answered me that they were dreading an attack from a "*sebâá*," and that if this should occur, one of us would be carried off without having time to put himself on the defensive. "I would rather be a spectator," I said to him, "than an actor in the scene you describe; consequently, I will give you two piastres more if you will keep your mule always in the center of the moving group." My proposal was accepted. It was then for the first time that I saw that my Arab carried a yatagan under his tunic, which he used for pricking on the mule the whole time that we were in the thicket. Superfluous cautions! The "*sebâá*" did not show himself.

Each village being a little republic, whose territory we could not cross without obtaining permission and a passport from the Mahomedan priest *président*, the priest who conducted our caravan used to leave us in the fields, and went sometimes a good way off to a village to solicit the permission, without which it would have been dangerous to continue our route. He remained entire hours without returning to us, and we then had occasion to reflect sadly on the imprudence of our enterprise. We generally slept among habitations. Once we found the streets of a village barricaded, because they were fearing an attack from a neighboring village. The foremost man of our caravan removed the obstacles; but a woman came out of her house like a fury, and belabored us with blows from a pole. We remarked that she was fair, of brilliant whiteness, and very pretty.

Another time we lay down in a lurking-place dignified by the beautiful name of Caravanseray. In the morning, when the sun rose, cries of "*Roumi! Roumi!*" warned us that we had been discovered. The sailor,

Mehemet, he who figured in the scene of the oath at Palamos, entered in a melancholy mood the inclosure where we were together, and made us understand that the cries of "Roumi!" vociferated under these circumstances, were equivalent to a sentence of death. "Wait," said he; "a means of saving you has occurred to me." Mehemet entered some moments afterward, told us that his means had succeeded, and invited me to join the Kabyls, who were going to say prayers.

I accordingly went out and prostrated myself toward the east. I imitated minutely the gestures which I saw made around me, pronouncing the sacred words, *La elah il Allah! oua Mahommed raçoul Allah!* It was the scene of Mamamouchi of the "Bourgeois Gentilhomme," which I had so often seen acted by Dugazon, with this one difference, that this time it did not make me laugh. I was, however, ignorant of the consequences it might have brought upon me on my arrival at Algiers. After having made the profession of faith before Mahomedans, *There is but one God, and Mahomet is his prophet*, if I had been informed against to the mufti, I must inevitably have become Mussulman, and they would not have allowed me to go out of the regency.

I must not forget to relate by what means Mehemet had saved us from inevitable death. "You have guessed rightly," said he to the Kabyls, "there are two Christians in the caravansary, but they are Mahomedans at heart, and are going to Algiers to be adopted by the mufti into our holy religion. You will not doubt this when I tell you that I was myself a slave to some Christians, and that they redeemed me with their money." "In cha Allah!" they exclaimed with one voice. And it was then that the scene took place which I have just described.

We arrived in sight of Algiers the 25th December, 1808. We took leave of the Arab owners of our mules, who walked on foot by the side of us, and we spurred them on in order to reach the town before the closing of the gates. On our arrival we learnt that the Dey, to whom we owed our first deliverance, had been beheaded. The guard of the palace before which we passed stopped us and questioned us as to whence we came. We replied that we came from Bougie by land. "It is not possible," exclaimed all the janissaries at once, "the Dey himself would not venture to undertake such a journey." "We acknowledge that we have committed a great imprudence, that we would not undertake to recommence the journey for millions; but the fact that we have just declared is the strict truth."

Arrived at the consular house we were, as on the first occasion, very cordially welcomed. We received a visit from a dragoman sent by the Dey, who asked whether we persisted in maintaining that Bougie had been our point of departure, and not Cape Matifou, or some neighboring part. We again affirmed the truth of our recital; it was confirmed the next day on the arrival of the proprietors of our mules.

At Palamos, during the various interviews which I had with the dowager Duchess of Orleans, one circumstance had particularly affected me.

The princess spoke to me unceasingly of the wish she had to go and rejoin one of her sons, whom she believed to be alive, but of whose death I had been informed by a person belonging to her household. Hence I was anxious to do all that lay in my power to mitigate a sorrow which she must experience before long.

At the moment when I quitted Spain for Marseilles, the duchess confided to me two letters which I was to forward in safety to their addresses. One was destined for the Empress-mother of Russia, the other for the Empress of Austria.

Scarcely had I arrived at Algiers when I mentioned these two letters to M. Dubois Thainville, and begged him to send them to France by the first opportunity. "I shall do nothing of the sort," he at once answered. "Do you know that you have behaved in this affair like a young inexperienced man, or to speak out, like a blunderer? I am surprised that you did not comprehend that the Emperor, with his pettish spirit, might take this much amiss, and consider you, according to the contents of the two letters, as the promoter of an intrigue in favor of the exiled family of the Bourbons." Thus the paternal advice of the French consul taught me that in all that regards politics, however nearly or remotely, one cannot give himself up, without danger, to the dictates of the heart and the reason.

I inclosed my two letters in an envelope bearing the address of a trustworthy person, and gave them into the hands of a corsair, who, after touching at Algiers, would proceed to France. I have never known whether they reached their destination.

The reigning Dey, successor to the beheaded Dey, had formerly filled the humble office of "*épileur*"* of dead bodies in the mosques. He governed the regency with much gentleness, occupying himself with little but his harem. This disgusted those who had raised him to this eminent post, and they resolved upon getting rid of him. We became aware of the danger which menaced him, by seeing the courts and vestibules of the consular house full, according to the custom under such circumstances, of Jews, carrying with them whatever they had of most value. It was a rule at Algiers that all that happened in the interval comprised between the death of a Dey and the installation of his successor could not be followed up by justice, and must remain unpunished. One can imagine, then, why the children of Moses should seek safety in the consular houses, the European inhabitants of which had the courage to arm themselves for self-defense as soon as the danger was apparent, and who, moreover, had a janissary to guard them.

While the unfortunate Dey "épileur" was being conducted toward the place where he was to be strangled, he heard the cannon which announced his death and the installation of his successor. "They are in great haste," said he, "what will you gain by carrying matters to ex-

*An "*épileur*" is a person who removes superfluous hairs. We have been unable to ascertain what office of this kind is performed in Mohamedan funerals.

tremities? Send me to the Levant; I promise you never to return. What have you to reproach me with?" "With nothing," answered his escort, "but your insignificance. However, a man cannot live as a mere private man, after having been Dey of Algiers." And the unfortunate man perished by the rope.

The communication by sea between Bougie and Algiers was not so difficult, even with the "*sandalas*," as the Caïd of the former town wished to assure me. Captain Spiro had the cases landed which belonged to me. The Caïd sought to discover what they contained; and having perceived through a chink something yellowish, he hastened to send the news to the Dey, that the Frenchmen who had come to Algiers by land had among their baggage cases filled with zechins, destined to revolutionize the Kabylie. They immediately had these cases forwarded to Algiers, and at their opening before the minister of naval affairs, all the phantasmagoria of zechins, of treasure, of revolution, disappeared at the sight of the stands and the limbs of several repeating circles in copper.

We are now going to sojourn several months in Algiers. I will take advantage of this to put together some details of manners, which may be interesting as the picture of a state of things anterior to that of the occupation of the regency by the French. This occupation, it must be remarked, has already fundamentally altered the manners and the habits of the Algerine population.

I am about to report a curious fact, and one which shows that politics, which insinuate themselves and bring discord into the bosom of the most united families, had succeeded, strange to say, in penetrating as far as the galley-slaves' prison at Algiers. The slaves belonged to three nations; there were in 1809 in this prison, Portuguese, Neapolitans, and Sicilians; among these two latter classes were counted partisans of Murat and those of Ferdinand of Naples. One day, at the beginning of the year, a dragoman came in the name of the Dey to beg M. Dubois Thainville to go without delay to the prison, where the friends of the French and their adversaries had involved themselves in a furious combat; and already several had fallen. The weapon with which they struck each other was the heavy long chain attached to their legs.

Each consul, as I said above, had a janissary placed with him as his guard; the one belonging to the French consul was a Candiote; he had been surnamed The Terror. Whenever some news unfavorable to France was announced in the cafés, he came to the consulate to inform himself as to the reality of the fact; and when we told him that the other janissaries had propagated false news, he returned to them, and there, yatagan in hand, he declared himself ready to enter the lists in combat against those who should still maintain the truth of the news. As these continual threats might endanger him (for they had no support beyond mere animal courage) we had wished to render him expert in the ing of arms by giving him some lessons in fencing; but he could

not endure the idea that Christians should touch him at every turn with foils; he therefore proposed to substitute for the simulated duel a real combat with the yatagan.

One may gain an exact idea of this savage nature when I mention that, having one day heard a pistol-shot, the sound of which proceeded from his room, people ran and found him bathed in his blood; he had just shot off a ball into his arm to cure himself of a rheumatic pain.

Seeing with what facility the Deys disappeared, I said one day to our janissary, "With this prospect before your eyes, would you consent to become Dey?" "Yes, doubtless," answered he. "You seem to count as nothing the pleasure of doing all that one likes, if only even for a single day!"

When we wished to take a turn in the town of Algiers, we generally took care to be escorted by the janissary attached to the consular house; it was the only means of escaping insults, affronts, and even acts of violence. I have just said it was the only means. I made a mistake; there was one other; that was, to go in the company of a French "lazarist" of seventy years of age, and whose name, if my memory serves me, was Father Joshua; he had lived in this country for a half a century. This man, of exemplary virtue, had devoted himself with admirable self-denial to the service of the slaves of the regency, and had divested himself of all considerations of nationality; the Portuguese, Neapolitans, Sicilians, all were equally his brethren.

In the times of plague he was seen day and night carrying eager help to the Mussulmans; thus his virtue had conquered even religious hatreds; and wherever he passed he and the persons who might accompany him received from multitudes of the people, from the janissaries, and even from the officials of the mosques, the most respectful salutations.

During our long hours of sailing on board the Algerine vessel, and our compulsory stay in the prisons at Rosas, and on the hulk at Palamos, I gathered some ideas as to the interior life of the Moors or the Coulougous, which, even now when Algiers has fallen under the dominion of France, would, perhaps, be yet worth preserving. I shall, however, confine myself to recounting, nearly word for word, a conversation which I had with Raïs Braham, whose father was a "*Turc fin*," that is to say, a Turk born in the Levant.

"How is it that you consent," said I to him, "to marry a young girl whom you have never seen, and find in her, perhaps, an excessively ugly woman, instead of the beauty whom you had fancied to yourself?"

"We never marry without having obtained information from the women who serve in the capacity of servants at the public baths. The Jewesses are, moreover, in these cases very useful go-betweens."

"How many legitimate wives have you?"

"I have four—that is to say, the number authorized by the Koran."

"Do they live together on a good understanding?"

"Ah, sir, my house is a hell. I never enter it without finding them at the step of the door, or at the bottom of the stairs; then each wants to be the first to make me listen to the complaints which she has to bring against her companions. I am about to utter blasphemy, but I think that our holy religion ought to prohibit a plurality of wives to those who are not rich enough to give to each a separate habitation."

"But since the Koran allows you to repudiate even legitimate wives, why do you not send back three of them to their parents?"

"Why? Because that would ruin me. On the day of the marriage the father of the young woman to be married stipulates for a dowry, and the half of it is paid. The other half may be exacted the day that the woman is repudiated. It would then be three half-dowries that I should have to pay if I sent back three of my wives. I ought, however, to rectify one inaccuracy in what I said just now, that my four wives had never agreed together. Once they were agreed among themselves in the feeling of a common hatred. In going through the market I had bought a young negress. In the evening, when I retired to rest, I perceived that my wives had prepared no bed for her, and that the unfortunate girl was extended on the ground. I rolled up my trowsers and laid them under her head as a kind of pillow. In the morning the distracting cries of the poor slave made me run to her, and I found her nearly sinking under the blows of my four wives; for once they understood each other marvelously well."

In February, 1809, the new Dey, the successor of the "épileur," a short time after having entered on his functions, claimed from two to three hundred thousand francs—I do not remember exactly the sum—which he pretended was due to him from the French government. M. Dubois Thainville answered that he had received the Emperor's orders not to pay one centime.

The Dey was furious, and decided upon declaring war against us. A declaration of war at Algiers used to be immediately followed by putting all the persons of other nations into prison. This time matters were not pushed to this extreme limit. Our names might be figuring on the list of the slaves of the regency; but, in fact, so far as I was concerned, I remained free in the consular house. By means of a pecuniary guarantee, contracted with the Swedish consul, M. Norderling, I was even permitted to live at his country-house, situated near the Emperor's fort.

The most insignificant event was sufficient to modify the ideas of these barbarians. I had come into the town one day, and was seated at table at M. Dubois Thainville's, when the English consul, Mr. Blankley, arrived in great haste, announcing to our consul the entrance into the port of a French prize. "I never will uselessly add," said he, generously, "to the severities of war; I came to announce to you, my colleague, that I will give up your prisoners on a receipt which will insure me the deliverance of an equal number of Englishmen detained in

'rance." "I thank you," answered M. Dubois Thainville; "but I do ot the less deplore this event that it will retard, indefinitely perhaps, he settlement of the account in which I am engaged with the Dey."

During this conversation, armed with a telescope, I was looking hrough the window of the dining-room, trying to persuade myself at ast that the captured vessel was not one of much importance. But ne must yield to evidence. It was pierced for a great number of guns. ll at once, the wind having displayed the flags, I perceived with sur- rise the French flag over the English flag. I communicated what I bserved to Mr. Blankley. He answered immediately, "You do not urely pretend to observe better with your bad telescope than I did with ıy *Dolland*?"

"And you cannot pretend," said I to him in *my* turn, "to see better han an astronomer by profession? I am sure of my fact. I beg M. 'hainville's permission, and will go this instant to visit this mysterious ırize."

In short, I went there; and this is what I learnt:

General Duhesme, Governor of Barcelona, wishing to rid himself of he most ill-disciplined portion of his garrison, formed the principal part nto the crew of a vessel, the command of which he gave to a lieutenant ıf Babastro, a celebrated corsair of the Mediterranean.

There were among these improvised seamen a hussar, a dragoon, two eterans, a miner with his long beard, &c. The vessel, leaving Bar. elona by night, escaped the English cruiser, and got to the entrance ıf Port Mahon. An English "lettre de marque" was coming out of the ort. The crew of the French vessel boarded her; and a furious com- at on the deck ensued, in which the French got the upper-hand. It vas this "lettre de marque" which had now arrived at Algiers.

Invested with full power by M. Dubois Thainville, I announced to the ırisoners that they were about to be immediately given up to their onsul. I respected even the trick of the captain, who, wounded by everal saber cuts, had contrived to cover up his head with his principal lag. I reassured his wife; but my chief care was especially devoted to passenger whom I saw, with one arm amputated.

"Where is the surgeon," I said to him, "who operated on you?"

"It was not our surgeon," he answered. "He basely fled with a part ıf the crew, and saved himself on land."

"Who, then, cut off your arm?"

"It was the hussar whom you see here."

"Unhappy man! I exclaimed, "what could lead you, when it was not your profession, to perform this operation?"

"The pressing request of the wounded man. His arm had already swollen to an enormous size. He wanted some one to cut it off for him with a blow of a hatchet. I told him that in Egypt, when I was in hos- pital, I had seen several amputations made; that I would imitate what I had seen, and might perhaps succeed That at any rate it would be

better than the blow of a hatchet. All was agreed; I armed myself with the carpenter's saw, and the operation was done."

I went off immediately to the American consul to claim the assistance of the only surgeon worthy of confidence who was then in Algiers. Mr. Triplet—I think I recollect that that was the name of the man of the distinguished art whose aid I invoked—came at once on board the vessel, examined the dressing of the wound, and declared, to my very lively satisfaction, that all was going on well, and that the Englishman would survive his horrible injury.

The same day we had the wounded men carried on litters to Mr. Blankley's house; this operation, executed with somewhat of ceremony, modified, though slightly, the feelings of the Dey in our favor, and his sentiments became yet more favorable toward us in consequence of another maritime occurrence, although a very insignificant one.

One day a corvette was seen in the horizon armed with a very great number of guns, and shaping her way toward the port of Algiers; there appeared immediately after an English brig of war in full sail; a combat was, therefore, expected, and all the terraces of the town were covered with spectators. The brig appeared to be the best sailer, and seemed to us likely to reach the corvette, but the latter tacked about, and seemed desirous to engage in battle; the English vessel fled before her; the corvette tacked about the second time, and again directed her course toward Algiers, where, one would have supposed, she had some special mission to execute. The brig in her turn now changed her course, but held herself constantly beyond the reach of shot from the corvette; at last the two vessels arrived in succession in the port, and cast anchor, to the lively disappointment of the Algerine population, who had hoped to be present without danger at a maritime combat between the "Christian dogs," belonging to two nations equally detested in a religious point of view; but shouts of laughter could not be repressed when it was seen that the corvette was a merchant vessel, and that she was only armed with wooden imitations of cannon. It was said in the town that the English sailors were furious, and had been on the point of mutiny against their too prudent captain.

I have very little to tell in favor of the Algerines; hence I must do an act of justice by mentioning that the corvette departed the next day for the Antilles, her destination, and that the brig was not permitted to set sail until the next day but one.

Bakri often came to the French consulate to talk of our affairs with M. Dubois Thainville. "What can you want?" said the latter; "you are an Algerine; you will be the first victim of the Dey's obstinacy. I have already written to Livorno that your families and your goods are to be seized. When the vessels laden with cotton, which you have in this port, arrive at Marseilles, they will be immediately confiscated; it is for you to judge whether it would not better suit you to pay the sum which the Dey claims than to expose yourself to tenfold and certain loss."

Such reasoning was unanswerable; and whatever it might cost him, Bakri decided on paying the sum that was demanded of France.

Permission to depart was immediately granted to us; I embarked the 21st of June, 1809, on board a vessel in which M. Dubois Thainville and his family were passengers.

The evening before our departure from Algiers, a corsair deposited at the consul's the Majorcan mail, which he had taken from a vessel which he had captured. It was a complete collection of the letters which the inhabitants of the Baléares had been writing to their friends on the Continent.

"Look here," said M. Dubois Thainville to me, "here is something to amuse you during the voyage, you who generally keep your room from sea-sickness; break the seals and read all these letters, and see whether they contain any accounts by which we might profit how to aid the unhappy soldiers who are dying of misery and despair in the little island of Cabrera."

Scarcely had we arrived on board the vessel, when I set myself to the work, and acted without scruple or remorse the part of an official of the black chamber, with this sole difference, that the letters were unsealed without taking any precautions. I found among them several dispatches in which Admiral Collingwood signified to the Spanish government the ease with which the prisoners might be delivered. Immediately on our arrival at Marseilles these letters were sent to the minister of naval affairs, who, I believe, did not pay much attention to them.

I knew almost every one at Palma, the capital of Majorca. I leave it to be imagined with what curiosity I read the missives in which the beautiful ladies of the town expressed their hatred against *los malditos cavachios*, (French,) whose presence in Spain had rendered necessary the departure for the Continent of a magnificent regiment of hussars; how many persons might I not have embroiled, if under a mask I had found myself with them at the opera ball!

Many of the letters made mention of me, and were particularly interesting to me; I was sure in this instance there was nothing to constrain the frankness of those who had written them. It is an advantage which few people can boast having enjoyed to the same degree.

The vessel in which I was, although laden with bales of cotton, had some corsair papers of the regency, and was the reputed escort of three richly laden merchant vessels which were going to France.

We were off Marseilles on the 1st of July, when an English frigate came to stop our passage: "I will not take you," said the English captain, "but you will go towards the Hyères Islands, and Admiral Collingwood will decide on your fate."

"I have received," answered the Barbary captain, "an express commission to conduct these vessels to Marseilles, and I will execute it."

"You, individually, can do what may seem to you best," answered the Englishman; "as to the merchant vessels under your escort, they will

be, I repeat to you, taken to Admiral Collingwood." And he immediately gave orders to those vessels to set sail to the east.

The frigate had already gone a little distance when she perceived that we were steering toward Marseilles. Having then learnt from the crews of the merchant vessels that we were ourselves laden with cotton, she tacked about to seize us.

She was very near reaching us, when we were enabled to enter the port of the little island of Pomègue. In the night she put her boats to sea to try to carry us off; but the enterprise was too perilous, and she did not dare attempt it.

The next morning, 2d of July, 1809, I disembarked at the lazaretto.

At the present day they go from Algiers to Marseilles in four days; it had taken me eleven months to make the same voyage. It is true that here and there I had made involuntary sojourns.

My letters sent from the lazaretto at Marseilles were considered by my relatives and friends as certificates of resurrection, they having for a long time past supposed me dead. A great geometer had even proposed to the Bureau of Longitude no longer to pay my allowance to my authorized representative; which appears the more cruel inasmuch as this representative was my father.

The first letter which I received from Paris was full of sympathy and congratulations on the termination of my laborious and perilous adventures; it was from a man already in possession of an European reputation, but whom I had never seen: M. de Humboldt, after what he had heard of my misfortunes, offered me his friendship. Such was the first origin of a connection which dates from nearly forty-two years back, without a single cloud ever having troubled it.

M. Dubois Thainville had numerous acquaintances in Marseilles; his wife was a native of that town, and her family resided there. They received, therefore, both of them, numerous visits in the parlor of the lazaretto. The bell which summoned them, for me alone was dumb; and I remained as solitary and forsaken, at the gates of a town peopled with a hundred thousand of my countrymen, as if I had been in the heart of Africa. One day, however, the parlor bell rang three times, (the number of times corresponding to the number of my room;) I thought it must be a mistake; I did not, however, allow this to appear. I traversed proudly under the escort of my guard of health the long space which separates the lazaretto, properly so called, from the parlor, and there I found, with very lively satisfaction, M. Pons, the director of the observatory at Marseilles, and the most celebrated discoverer of comets of whom the annals of astronomy have ever had to register the success.

At any time a visit from the excellent M. Pons, whom I have since seen director of the observatory at Florence, would have been very agreeable to me; but during my quarantine I felt it unappreciably valuable. It proved to me that I had returned to my native soil.

Two or three days before our admission to freedom, we experienced a loss which was deeply felt by each of us. To pass away the heavy time of a severe quarantine, the little Algerine colony was in the habit of going to an inclosure near the lazaretto, where a very beautiful gazelle, belonging to M. Dubois Thainville, was confined; she bounded about there in full liberty with a grace which excited our admiration. One of us endeavored to stop this elegant animal in her course; he seized her unluckily by the leg, and broke it. We all ran, but only, alas! to witness a scene which excited the deepest emotion in us.

The gazelle, lying on her side, raised her head sadly; her beautiful eyes (the eyes of a gazelle!) shed torrents of tears; no cry of complaint escaped her mouth; she produced that effect upon us which is always felt when a person who is suddenly struck by an irreparable misfortune, resigns himself to it, and shows his profound anguish only by silent tears.

Having ended my quarantine, I went at once to Perpignan, to the bosom of my family, where my mother, the most excellent and pious of women, caused numerous masses to be said to celebrate my return, as she had done before to pray for the repose of my soul, when she thought that I had fallen under the daggers of the Spaniards. But I soon quitted my native town to return to Paris; and I deposited at the Bureau of Longitude and the Academy of Sciences my observations, which I had succeeded in preserving amidst the perils and tribulations of my long campaign.

A few days after my arrival, on the 18th of September, 1809, I was nominated an academician in the place of Lalande. There were fifty-two voters; I obtained forty-seven voices, M. Poisson four, and M. Nouet one. I was then twenty-three years of age.

A nomination made with such a majority would appear, at first sight, as if it would give rise to no serious difficulties; but it proved otherwise. The intervention of M. de Laplace, before the day of ballot, was active and incessant to have my admission postponed until the time when a vacancy, occurring in the geometry section, might enable the learned assembly to nominate M. Poisson at the same time as me. The author of the *Mécanique Céleste* had vowed to the young geometer an unbounded attachment, completely justified, certainly, by the beautiful researches which science already owed to him. M. de Laplace could not support the idea that a young astronomer, younger by five years than M. Poisson, a pupil, in the presence of his professor at the Polytechnic School, should become an academician before him. He proposed to me, therefore, to write to the Academy that I would not stand for election until there should be a second place to give to Poisson. I answered by a formal refusal, and giving my reasons in these terms: "I care little to be nominated at this moment. I have decided upon leaving shortly with M. de Humboldt for Thibet. In those savage regions the title of member of the Institute will not smooth the difficulties which we shall have to encounter. But

I would not be guilty of any rudeness toward the Academy. If they were to receive the declaration for which I am asked, would not the savans who composed this illustrious body have a right to say to me: "How are you certain that we have thought of you? You refuse what has not yet been offered to you.'"

On seeing my firm resolution not to lend myself to the inconsiderate course which he had advised me to follow, M. de Laplace went to work in another way: he maintained that I had not sufficient distinction for admission into the Academy. I do not pretend that, at the age of three-and-twenty, my scientific attainments were very considerable, if estimated in an *absolute* manner; but when I judged by *comparison*, I regained courage, especially on considering that the three last years of my life had been consecrated to the measurement of an arc of the meridian in a foreign country; that they were passed amid the storms of the war with Spain; often enough in dungeons, or, what was yet worse, in the mountains of Kabylia, and at Algiers, at that time a very dangerous residence.

Here is, therefore, my statement of accounts for that epoch. I make it over to the impartial appreciation of the reader:

On leaving the Polytechnic School, I had made, in conjunction with M. Biot, an extensive and very minute research on the determination of the coefficient of the tables of atmospheric refraction.

We had also measured the refraction of different gases, which, up to that time, had not been attempted.

A determination, more exact than had been previously obtained, of the relation of the weight of air to the weight of mercury, had furnished a direct value of the coefficient of the barometrical formula which served for the calculation of the heights.

I had contributed, in a regular and very assiduous manner, during nearly two years, to the observations which were made day and night with the transit telescope and with the mural quadrant at the Paris Observatory.

I had undertaken, in conjunction with M. Bouvard, the observations relating to the verification of the laws of the moon's libration. All the calculations were prepared; it only remained for me to put the numbers into the formulæ, when I was, by order of the Bureau of Longitude, obliged to leave Paris for Spain. I had observed various comets, and calculated their orbits. I had, in concert with M. Bouvard, calculated, according to Laplace's formula, the table of refraction which has been published in the *Recueil des Tables* of the Bureau of Longitude, and in the *Connaissance des Temps*. A research on the velocity of light, made with a prism placed before the object end of the telescope of the mural circle, had proved that the same tables of refraction might serve for the sun and all the stars.

Finally, I had just terminated, under very difficult circumstances, the

grandest triangulation which had ever been achieved, to prolong the meridian line from France as far as the Island of Formentera.

M. de Laplace, without denying the importance and utility of these labors and these researches, saw in them nothing more than indications of promise; M. Lagrange then said to him explicitly:

"Even you, M. de Laplace, when you entered the Academy, had done nothing brilliant; you only gave promise. Your grand discoveries did not come till afterward."

Lagrange was the only man in Europe who could with authority address such an observation to him.

M. de Laplace did not reply upon the ground of the personal question, but he added, "I maintain that it is useful to young savans to hold out the position of member of the Institute as a future recompense, to excite their zeal."

"You resemble," replied M. Hallé, "the driver of the hackney coach, who, to excite his horses to a gallop, tied a bundle of hay at the end of his carriage pole; the poor horses redoubled their efforts, and the bundle of hay always flew on before them. After all, his plan made them fall off, and soon after brought on their death."

Delambre, Legendre, Biot, insisted on the devotion, and what they termed the courage, with which I had combated arduous difficulties, whether in carrying on the observations, or in saving the instruments and the results already obtained. They drew an animated picture of the dangers I had undergone. M. de Laplace ended by yielding when he saw that all the most eminent men of the Academy had taken me under their patronage, and on the day of the election he gave me his vote. It would be, I must own, a subject of regret with me even to this day, after a lapse of forty-two years, if I had become member of the Institute without having obtained the vote of the author of the *Mécanique Céleste.*

The members of the Institute were always presented to the Emperor after he had confirmed their nominations. On the appointed day, in company with the presidents, with the secretaries of the four classes, and with the academicians who had special publications to offer to the Chief of the State, they assembled in one of the saloons of the Tuileries. When the Emperor returned from mass, he held a kind of review of these savans, these artists, these literary men, in green uniform.

I must own that the spectacle which I witnessed on the day of my presentation did not edify me. I even experienced real displeasure in seeing the anxiety evinced by members of the Institute to be noticed.

"You are very young," said Napoleon to me on coming near me; and without waiting for a flattering reply, which it would not have been difficult to find, he added, "What is your name?" And my neighbor on the right, not leaving me time to answer the simple enough question just addressed to me, hastened to say:

"*His* name is Arago."

"What science do you cultivate?"

My neighbor on the left immediately replied—

"*He* cultivates astronomy."

"What have you done?"

My neighbour on the right, jealous of my left hand neighbor for having encroached on his rights at the second question, now hastened to reply, and said:

"*He* has just been measuring the line of the meridian in Spain."

The Emperor, imagining doubtless that he had before him either a dumb man or an imbecile, passed on to another member of the Institute. This one was not a novice, but a naturalist well known through his beautiful and important discoveries, it was M. Lamarck. The old man presented a book to Napoleon.

"What is that?" said the latter, "it is your absurd *meteorology*, in which you rival Matthieu Laensberg. It is this 'annuaire' which dishonors your old age. Do something in natural history, and I should receive your productions with pleasure. As to this volume, I only take it in consideration of your white hair. Here!" And he passed the book to an aide-de-camp.

Poor M. Lamarck, who, at the end of each sharp and insulting sentence of the Emperor, tried in vain to say, "It is a work on natural history which I present to you," was weak enough to fall into tears.

The Emperor immediately afterward met with a more energetic antagonist in the person of M. Lanjuinais. The latter had advanced, book in hand. Napoleon said to him, sneeringly:

"The entire Senate, then, is to merge in the Institute?" "Sire," replied Lanjuinais, "it is the body of the state to which most time is left for occupying itself with literature."

The Emperor, displeased at this answer, at once quitted the civil uniforms, and busied himself among the great epaulettes which filled the room.

Immediately after my nomination I was exposed to strange annoyances on the part of the military authorities. I had left for Spain, still holding the title of pupil of the Polytechnic School. My name could not remain on the books more than four years; consequently I had been enjoined to return to France to go through the examinations necessary on quitting the school. But in the meantime Lalande died, and thus a place in the Bureau of Longitude became vacant. I was named assistant astronomer. These places were submitted to the nomination of the Emperor. M. Lacuée, director of the conscription, thought that, through this latter circumstance, the law would be satisfied, and I was authorized to continue my operations.

M. Matthieu Dumas, who succeeded him, looked at the question from an entirely different point of view; he enjoined me either to furnish a substitute, or else set off myself with the contingent of the twelfth arrondissement of Paris.

All my remonstrances and those of my friends having been fruitless, announced to the honorable general that I should present myself in the Place de l'Estrapade, whence the conscripts had to depart, in the costume of a member of the Institute; and that thus I should march on foot through the city of Paris. General Matthieu Dumas was alarmed at the effect which this scene would produce on the Emperor, himself a member of the Institute, and hastened, under fear of my threat, to confirm the decision of General Lacuée.

In the year 1809, I was chosen by the "conseil du perfectionnement" of the Polytechnic School to succeed M. Monge, in his chair of analysis applied to geometry. The circumstances attending that nomination have remained a secret; I seize the first opportunity which offers itself to me to make them known.

M. Monge took the trouble to come to me one day, at the observatory, to ask me to succeed him. I declined this honor, because of a proposed journey which I was going to make into Central Asia with M. de Humboldt. "You will certainly not set off for some months to come," said the illustrious geometer; "you could, therefore, take my place temporarily." "Your proposal," I replied, "flatters me infinitely; but I do not know whether I ought to accept it. I have never read your great work on partial differential equations; I do not, therefore, feel certain that I should be competent to give lessons to the pupils of the Polytechnic School on such a difficult theory." "Try," said he, "and you will find that that theory is clearer than it is generally supposed to be." Accordingly, I did try; and M. Monge's opinion appeared to me to be well founded.

The public could not comprehend, at that time, how it was that the benevolent M. Monge obstinately refused to confide the delivery of his course to M. Binet, (a private teacher under him,) whose zeal was well known. It is this motive which I am going to reveal.

There was then in the "Bois de Boulogne" a residence named the Grey House, where there assembled around M. Coessin, the high-priest of a new religion, a number of adepts, such as Lesueur, the musician, Colin, private teacher of chemistry at the school, M. Binet, &c. A report from the prefect of police had signified to the Emperor that the frequenters of the Grey House were connected with the Society of Jesuits. The Emperor was uneasy and irritated at this. "Well," said he to M. Monge, "there are your dear pupils become disciples of Loyola!" And on Monge's denial, "You deny it," answered the Emperor; "well, then, know that the private teacher of your course is in that clique." Every one can understand that after such a remark, Monge could not consent to being succeeded by M. Binet.

Having entered the Academy, young, ardent, and impassioned, I took much greater part in the nominations than may have been suitable for my position and my time of life. Arrived at an epoch of life whence I examine retrospectively all my actions with calmness and impartiality,

I can render this amount of justice to myself, that, excepting in three or four instances, my vote and interest were always in favor of the most deserving candidate, and more than once I succeeded in preventing the Academy from making a deplorable choice. Who could blame me for having maintained with energy the election of Malus, considering that his competitor, M. Girard, unknown as a physicist, obtained twenty-two votes out of fifty-three, and that an addition of five votes would have given him the victory over the savant who had just discovered the phenomenon of polarization by reflection, over the savant whom Europe would have named by acclamation? The same remarks are applicable to the nomination of Poisson, who would have failed against this same M. Girard if four votes had been otherwise given. Does not this suffice to justify the unusual ardor of my conduct? Although in a third trial the majority of the Academy was decided in favor of the same engineer, I cannot regret that I supported up to the last moment with conviction and warmth the election of his competitor, M. Dulong.

I do not suppose that, in the scientific world, any one will be disposed to blame me for having preferred M. Liouville to M. de Pontécoulant.

Sometimes it happened that the government wished to influence the choice of the Academy; with a strong sense of my rights I invariably resisted all dictation. Once this resistance acted unfortunately on one of my friends—the venerable Legendre; as to myself, I had prepared myself beforehand for all the persecutions of which I could be made the object. Having received from the minister of the interior an invitation to vote for M. Binet against M. Navier on the occurrence of a vacant place in the section of mechanics, Legendre nobly answered that he would vote according to his soul and his conscience. He was immediately deprived of a pension which his great age and his long services rendered due to him. The *protégé* of the authorities failed; and, at the time, this result was attributed to the activity with which I enlightened the members of the Academy as to the impropriety of the minister's proceedings.

On another occasion the King wished the Academy to name Dupuytren, the eminent surgeon, but whose character at the time lay under grave imputations. Dupuytren was nominated, but several blanks protested against the interference of the authorities in academic elections.

I said above that I had saved the Academy from some deplorable choices: I will only cite a single instance, on which occasion I had the sorrow of finding myself in opposition to M. de Laplace. The illustrious geometer wished a vacant place in the astronomical section to be granted to M. Nicollet—a man without talent. At the close of a contest, which I maintained undisguisedly, notwithstanding the danger which might follow from thus braving the powerful protectors of M. Nicollet, the Academy proceeded to the ballot; the respected M. Damoiseau, whose election I had supported, obtained forty-five votes out of forty-eight. Thus M. Nicollet had collected but three.

"I see," said M. de Laplace to me, "that it is useless to struggle

gainst young people; I acknowledge that the man who is called the *reat elector* of the Academy is more powerful than I am."

"No," replied I; "M. Arago can only succeed in counterbalancing he opinion justly preponderating for M. de Laplace, when the right is ound to be without possible contradiction on his side."

I would warn those savants, who having early entered the Academy, night be tempted to imitate my example, to expect nothing beyond the atisfaction of their conscience. I warn them, with a knowledge of the ase, that gratitude will almost always be found wanting.

The elected Academician, whose merits you have sometimes exalted beyond measure, pretends that you have done no more than justice to him; that you have only fulfilled a duty, and that he therefore owes you no thanks.

Delambre died the 19th August, 1822. After the necessary delay, they proceeded to fill his place. The situation of perpetual secretary is not one which can long be left vacant. The Academy named a commission to present it with candidates; it was composed of Messrs. de Laplace, Arago, Legendre, Rossel, Prony, and Lacroix. The list presented was composed of the names of Messrs. Biot, Fourier, and Arago. It is not necessary for me to say with what obstinacy I opposed the inscription of my name on this list; I was compelled to give way to the will of my colleagues, but I seized the first opportunity of declaring publicly that I had neither the expectation nor the wish to obtain a single vote; that, moreover, I had on my hands already as much work as I could get through; that in this respect M. Biot was in the same position; and that, in short, I should vote for the nomination of M. Fourier.

It was supposed, but I dare not flatter myself that it was the fact, that my declaration exercised a certain influence on the result of the ballot. The result was as follows: M. Fourier received thirty-eight votes, and M. Biot ten. In a case of this nature each man carefully conceals his vote, in order not to run the risk of future disagreement with him who may be invested with the authority which the Academy gives to the perpetual secretary. I do not know whether I shall be pardoned if I recount an incident which amused the Academy at the time.

M. de Laplace, at the moment of voting, took two plain pieces of paper; his neighbor was guilty of the indiscretion of looking, and saw distinctly that the illustrious geometer wrote the name of Fourier on both of them. After quietly folding them up, M. de Laplace put the papers into his hat, shook it, and said to this same curious neighbor: "You see, I have written two papers; I am going to tear up one; I shall put the other into the urn; I shall thus be myself ignorant for which of the two candidates I have voted."

All went on as the celebrated Academician had said; only that every one knew with certainty that his vote had been for Fourier; and "the calculation of probabilities" was in no way necessary for arriving at this result.

After having fulfilled the duties of secretary with much distinction, but not without some feebleness and negligence in consequence of his bad health, Fourier died the 16th of May, 1830. I declined several times the honor which the Academy appeared willing to do me, in naming me to succeed him. I believed, without false modesty, that I had not the qualities necessary to fill this important place suitably. When thirty-nine out of forty-four voters had appointed me, it was quite time that I should give in to an opinion so flattering and so plainly expressed. On the 7th of June, 1830, I, therefore, became perpetual secretary of the Academy for the Mathematical Sciences; but, conformably to the plea of an accumulation of offices, which I had used as an argument to support, in November, 1822, the election of M. Fourier, I declared that I should give in my resignation of the professorship in the Polytechnic School. Neither the solicitations of Marshal Soult, the minister of war, nor those of the most eminent members of the Academy, could avail in persuading me to renounce this resolution.

HERSCHEL.

By M. Arago.

William Herschel, one of the greatest astronomers that ever lived in any age or country, was born at Hanover, on the 15th of November, 1738. The name of Herschel has become too illustrious for the world to neglect searching back, along the stream of time, to learn the social position of the families that have borne it. Yet pardonable curiosity on this subject has not been entirely satisfied. We only know that Abraham Herschel, great-grandfather of the astronomer, resided at Mähren, whence he was expelled on account of his strong attachment to the Protestant faith; that Abraham's son Isaac was a farmer in the vicinity of Leipzig; that Isaac's eldest son, Jacob Herschel, disappointed his father's earnest desire to see him devote himself to agriculture, that he determined on being a musician, and settled at Hanover.

Jacob Herschel, father of William, the astronomer, was an eminent musician, not less remarkable for the good qualities of his heart than for those of his mind. His very limited means did not enable him to bestow a complete education on his family, consisting of six boys and four girls, although, by his care, his ten children all became excellent musicians. The eldest, Jacob, even acquired a rare degree of skill, which procured for him the appointment of master of the band in a Hanoverian regiment, which he accompanied to England. The third son, William, remained under his father's roof, and, without neglecting the fine arts, took lessons in the French language, and devoted himself to the study of metaphysics, for which he retained a taste to his latest day.

In 1759 William Herschel, then about twenty-one years of age, went over to England, not with his father, as has been erroneously stated, but with his brother Jacob, whose connections in that country seemed likely to favor the young man's opening prospects in life. But neither London nor the country towns afforded him any resource in the beginning, and the first two or three years after his expatriation were marked with cruel privations, which were, however, manfully endured. A fortunate chance finally raised the young Hanoverian to a better position; Lord Durham engaged him as master of the band in an English regiment which was quartered on the borders of Scotland. From this moment he began to acquire a reputation as a musician that was gradually extended, until in 1766 he was appointed organist at Halifax, (Yorkshire.) The emoluments of this situation, together with those of giving private lessons both in the town and the country around, afforded him the means to remedy, or rather to complete, his early education. It was

then that he learned Latin and Italian, though without any other help than a grammar and a dictionary, and that he also acquired some knowledge of Greek. So great was the desire for knowledge with which he was inspired that while residing at Halifax he found means to continue his philological exercises, and at the same time to study deeply the learned but very obscure mathematical work of Smith on the theory of music. This treatise, either explicitly or implicitly, supposed the reader to have a knowledge of algebra and geometry, which Herschel did not possess, but of which he made himself master in a very short time.

In 1766 Herschel obtained the appointment of organist to the Octagon Chapel at Bath. This was a more lucrative post than that at Halifax, but it also devolved on him new obligations. He had to play incessantly either at the oratorios, or in the rooms at the baths, at the theater, and in the public concerts. Besides this, from among his patrons in the most fashionable circle of England, he could not refuse to take numerous pupils who wished to be instructed in his art. It is difficult to imagine how, among so many duties, so many distractions of various kinds, Herschel could continue the studies, which even at Halifax had required so much resolution and perseverance, with a very uncommon degree of talent. We have seen that it was by music that Herschel was led to mathematics; mathematics in their turn led him to optics, the principal and fertile source of his illustrious career. The time finally arrived when his theoretic knowledge was to guide the young musician into a laborious application of principles quite foreign to his habits; and of which the brilliant success, as well as the excessive temerity, must excite reasonable astonishment.

A telescope—a simple reflector, only two English feet in length falls into the hands of Herschel during his residence at Bath. This instrument, however imperfect, shows him a multitude of stars in the sky that the naked eye cannot discern; shows him also enlarged known objects, under their true dimensions; reveals forms to him that the richest imaginations of antiquity had never suspected. He is transported with enthusiasm, and resolves, without delay, to have a similar instrument but of larger size. The answer from London is delayed for some days. These few days appear to him as years. When the answer arrives, the price that the optician demands proves to be much beyond the pecuniary resources of a mere organist. To any other man this would have been an unsurmountable obstacle. This unexpected difficulty, on the contrary, inspired Herschel with fresh energy. He cannot buy a telescope; then he will construct one with his own hands. The musician of the Octagon Chapel rushes immediately into a multitude of experiments, on metallic alloys that reflect light with the greatest intensity, on the means of giving the parabolic figure to the mirrors, on the causes that in the operation of polishing affect the regularity of the reflection, &c. So rare a degree of perseverance at last receives its reward. In 1774 Herschel has the happiness of being

able to examine the heavens with a Newtonian telescope of five English feet focus, entirely made by himself. This success tempts him to undertake still more difficult enterprises. Other telescopes of seven, of eight, of ten, and even of twenty feet focal distance, crown his efforts. As if to answer in advance those critics who would have accused him of a superfluity of apparatus, of unnecessary luxury, in the large size of the new instruments, and his extreme minutiæ in their execution, Nature granted to the astronomical musician, on the 13th of March, 1781, the unprecedented honor of commencing his career of observation with the discovery of a new planet, situated on the confines of our solar system. Dating from that moment, Herschel's reputation, no longer in his character of musician, but as a constructor of telescopes and as an astronomer, spread throughout the world. George III, a lover of science, and much inclined besides to protect and patronize both men and things of Hanoverian origin, had Herschel presented to him. He was charmed with the simple yet lucid and modest account that the astronomer gave of his repeated endeavors; he caught a glimpse of the glory that such an observer might reflect on his reign; granted him a pension of three hundred guineas a year, and furnished him with a residence near Windsor Castle, first at Clay Hall and then at Slough. The anticipations of George III were completely realized. We may confidently assert, relative to the little house at Slough, that it is the place of all the world where the greatest number of astronomical discoveries have been made. The name of that village will never perish. Science will transmit it religiously to our latest posterity.

I shall avail myself of this opportunity to rectify a mistake, of which ignorance and idleness wish to make a triumphant handle, or, at all events, to wield in their cause as an irresistible justification. It has been repeated to satiety that at the time when Herschel entered on his astronomical career he knew nothing of mathematics. But I have already said that, during his residence at Bath, the organist of the Octagon Chapel had familiarized himself with the principles of geometry and algebra; and a still more positive proof of this is, that a difficult question on the vibration of strings loaded with small weights having been proposed for discussion in 1779, Herschel gave it a solution which was thought worthy to be inserted in several scientific periodicals of the year 1780.

The adventurous life of Herschel is here closed. The great astronomer will not quit his observatory any more, except to submit the sublime results of his laborious vigils to the Royal Society of London. These results are contained in his memoirs; they constitute one of the principal riches of the celebrated collection known under the title of *Philosophical Transactions.*

Herschel was even elected as a member of the principal academies of Europe, and about 1816 he was named a Knight of the Guelphic Order of Hanover. According to the English custom, from the time of that

nomination the title of Sir William took the place, on all his memoirs, already honored with so much celebrity, of the former appellation of Doctor William. He had been named a doctor of laws in the University of Oxford in 1786. This dignity, by special favor, was conferred on him without any of the obligatory formalities of examination, disputation, or pecuniary contribution, usual in that learned corporation.

I should wound the elevated sentiments that Herschel professed all his life, if I were not here to mention two indefatigable assistants that this fortunate astronomer found in his own family. The one was Alexander Herschel, endowed with a remarkable talent for mechanism, always at his brother's service, and who enabled him to realize without delay any ideas that he had conceived;* the other was Miss Caroline Herschel, who deserves a still more particular and detailed mention.

Miss Caroline Lucretia Herschel went to England as soon as her brother became special astronomer to the King. She received the appellation there of Assistant Astronomer, with a moderate salary. From that moment she unreservedly devoted herself to the service of her brother, happy in contributing night and day to his rapidly increasing scientific reputation. Miss Caroline shared in all the night-watches of her brother, with her eye constantly on the clock, and the pencil in her hand; she, without exception, recorded all the observations; she afterward made three or four copies in separate registers; coördinated, classed, and analyzed them. If the scientific world saw with astonishment how Herschel's works succeeded each other with unexampled rapidity during so many years, they were specially indebted for it to the ardor of Miss Caroline. Astronomy, moreover, has been directly enriched with several comets by this excellent and respectable lady. After the death of her illustrious brother, she retired to Hanover, to the house of Jahn Dietrich Herschel, a musician of high reputation, and the only surviving brother of the astronomer.

William Herschel died without pain on the 23d of August, 1822, aged eighty-three. Neither fame nor fortune ever changed in him the fund of infantine candor, inexhaustible benevolence, and sweetness of character with which nature had endowed him. He preserved to the last both his brightness of mind and vigor of intellect. For some years before his death he enjoyed with delight the distinguished success of his only son,† Sir John Herschel. At his last hour he sunk to rest with the pleasing conviction that his beloved son, heir of a great name, would not allow it to fall into oblivion, but would adorn it with fresh luster.

* When age and infirmities obliged Alexander Herschel to give up his profession as a musician, he quitted Bath and returned to Hanover, very generously provided by Sir William with a comfortable independence for life.

† Sir W. Herschel had married Mary, the widow of John Pitt, esq., possessed of a considerable jointure, and the union proved a remarkable accession of domestic happiness. This lady survived Sir William by several years. They had but this son.—TRANSLATOR'S NOTE.

and that great discoveries would also honor his career. No prediction of the illustrious astronomer has been more completely verified.

In the English journals an account is given of the interesting means adopted by the family of Sir William Herschel for preserving the remains of the great telescope of thirty-nine feet focus, constructed by that celebrated astronomer.

The metal tube of the instrument, carrying at one end the recently cleaned mirror of four feet ten inches in diameter, has been placed horizontally in the meridian on solid piers of masonry, in the midst of the circle where formerly stood the mechanism requisite for maneuvering the telescope. The 1st of January, 1840, Sir John Herschel, his wife, their children, seven in number, and some old family-servants assembled at Slough. Exactly at noon the party walked several times in procession around the instrument; they then entered the tube of the telescope, seated themselves on benches that had been prepared for the purpose, and sung a requiem, with English words, composed by Sir John Herschel himself. After their exit, the illustrious family ranged themselves around the great tube, the opening of which was then hermetically sealed. The day concluded with a party of intimate friends.

I know not whether those persons who can only appreciate things from the peculiar point of view from which they have been accustomed to look, may think there was something strange in several of the details of the ceremony that I have just described. I affirm, however, that the whole world will applaud the pious feeling which actuated Sir John Herschel, and that all the friends of science will thank him for having consecrated the humble garden where his father achieved such immortal labors by a monument more expressive in its simplicity than pyramids or statues.

CHRONOLOGICAL TABLE OF THE MEMOIRS OF WILLIAM HERSCHEL.*

1780. *Philosophical Transactions*, vol. lxx.—Astronomical observations on the periodical star in the neck of the Whale.—Astronomical observations relative to the lunar mountains.

1781. *Phil. Trans.*, vol. lxxi.—Astronomical observations on the rotation of the planets on their axes, made with a view to decide whether the daily rotation of the earth be always the same.—On the comet of 1781, afterward called the *Georgium Sidus.*

1782. *Phil. Trans.*, vol. lxxii.—On the parallax of the fixed stars.—Catalogue of double stars.—Description of a lamp micrometer, and the method of using it.—Answers to the doubts that might be raised to the high magnifying powers used by Herschel.

1783. *Phil. Trans.*, vol. lxxiii.—Letter to Sir Joseph Banks on the name to be given to the new planet.—On the diameter of the Georgium Sidus, followed by the description of a micrometer with luminous or dark disks.—On the proper motion of the solar system, and the various changes that have occurred among the fixed stars since the time of Flamsteed.

1784. *Phil. Trans.*, vol. lxxiv.—On some remarkable appearances in the polar regions of Mars, the inclination of its axis, the position of its poles, and its spheroidal form.—

* These titles are copied direct from the Philosophical Transactions, instead of being re-translated.—TRANSLATOR'S NOTE.

Some details on the real diameter of Mars, and on its atmosphere.—Analysis of some observations on the constitution of the heavens.

1785. *Phil. Trans.*, vol. lxxv.—Catalogue of double stars.—On the constitution of the heavens.

1786. *Phil. Trans.*, vol. lxxvi.—Catalogue of a thousand nebulæ and clusters of stars.—Researches on the cause of a defect of definition in vision, which has been attributed to the smallness of the optic pencils.

1787. *Phil. Trans.*, vol. lxxvii.—Remarks on the new comet.—Discovery of two satellites revolving round George's Planet.—On th ree volcanoes in the moon.

1788. *Phil. Trans.*, vol. lxxviii.—On George's Planet (Uranus) and its satellites.

1789. *Phil. Trans.*, vol. lxxix.—Observations on a comet.—Catalogue of a second thousand new nebulæ and clusters of stars.—Some preliminary remarks on the constitution of the heavens.

1790. *Phil. Trans.*, vol. lxxx.—Discovery of Saturn's sixth and seventh satellites; with remarks on the constitution of the ring, on the planet's rotation round an axis, on its spheroidal form, and on its atmosphere.—On Saturn's satellites, and the rotation of the ring round an axis.

1791. *Phil. Trans.*, vol. lxxxi.—On the nebulous stars and the suitableness of this epithet.

1792. *Phil. Trans.*, vol. lxxxii.—On Saturn's ring, and the rotation of the planet's fifth satellite round an axis.—Mixed observations.

1793. *Phil. Trans.*, vol. lxxxiii.—Observations on the planet Venus.

1794. *Phil. Trans.*, vol. lxxxiv.—Observations on a quintuple band in Saturn.—On some peculiarities observed during the last solar eclipse.—On Saturn's rotation round an axis.

1795.—*Phil. Trans.*, vol. lxxxv.—On the nature and physical constitution of the sun and stars.—Description of a reflecting telescope forty feet in length.

1796. *Phil. Trans.*, vol. lxxxvi.—Method of observing the changes that happen to the fixed stars; remarks on the stability of our sun's light.—Catalogue of comparative brightness, to determine the permanency of the luster of stars.—On the periodical star *α* Herculis, with remarks tending to establish the rotatory motion of the stars on their axes; to which is added a second catalogue of the brightness of the stars.

1797. *Phil. Trans.*, vol. lxxxvii.—A third catalogue of the comparative brightness of the stars; with an introductory account of an index to Mr. Flamsteed's observations of the fixed stars, contained in the second volume of the Historia Cœlestis, to which are added several useful results derived from that index.—Observations of the changeable brightness of the satellites of Jupiter, and of the variation in their apparent magnitudes; with a determination of the time of their rotary motions on their axes, to which is added a measure of the diameter of the second satellite, and an estimate of the comparative size of the fourth.

1798. *Phil. Trans.*, vol. lxxxviii.—On the discovery of four additional satellites of the Georgium Sidus. The retrograde motion of its satellites announced; and the cause of their disappearance at certain distances from the planet explained.

1799. *Phil. Trans.*, vol. lxxxix.—A fourth catalogue of the comparative brightness of the stars.

1800. *Phil. Trans.*, vol. xc.—On the power of penetrating into space by telescopes, with a comparative determination of the extent of that power in natural vision, and in telescopes of various sizes and construction; illustrated by select observations.—Investigation of the powers of the prismatic colors to heat and illuminate objects; with remarks that prove the different refrangibility of radiant heat; to which is added an inquiry into the method of viewing the sun advantageously with telescopes of large apertures and high magnifying powers.—Experiments on the refrangibility of the invisible rays of the sun.—Experiments on the solar and on the terrestrial rays that occasion heat; with a comparative view of the laws to which light and heat, or rather the rays which occasion them, are subject, in order to determine whether they are the same or different.

1801. *Phil. Trans.*, vol. xci.—Observations tending to investigate the nature of the sun, in order to find the causes or symptoms of its variable emission of light and heat; with remarks on the use that may possibly be drawn from solar observations.—Additional observations tending to investigate the symptoms of the variable emission of the light and heat of the sun; with trials to set aside darkening glasses, by transmitting the solar rays through liquids, and a few remarks to remove objections that might be made against some of the arguments contained in the former paper.

1802. *Phil. Trans.*, vol. xcii.—Observations on the two lately discovered celestial bodies, (Ceres and Pallas.)—Catalogue of 500 new nebulæ and clusters of stars, with remarks on the construction of the heavens.

1803. *Phil. Trans.*, vol. xciii.—Observations of the transit of Mercury over the disk of the sun; to which is added an investigation of the causes which often prevent the proper action of mirrors.—Account of the changes that have happened during the last wenty-five years in the relative situation of double stars; with an investigation of the cause to which they are owing.

1804. *Phil. Trans.*, vol. xciv.—Continuation of an account of the changes that have happened in the relative situation of double stars.

1805. *Phil. Trans.*, vol. xcv.—Experiments for ascertaining how far telescopes will enable us to determine very small angles, and to distinguish the real from the spurious diameters of celestial and terrestrial objects; with an application of the result of these experiments to a series of observations on the nature and magnitude of Mr. Harding's lately discovered star.—On the direction and velocity of the motion of the sun and solar system.—Observation on the singular figure of the planet Saturn.

1806. *Phil. Trans.*, vol. xcvi.—On the quantity and velocity of the solar motion.—Observations on the figure, the climate, and the atmosphere of Saturn and its ring.

1807. *Phil. Trans.*, vol. xcvii.—Experiments for investigating the cause of the colored concentric rings discovered by Sir Isaac Newton between two object-glasses laid one upon another.—Observations on the nature of the new celestial body discovered by Dr. Olbers, and of the comet which was expected to appear last January, in its return from the sun.

1808. *Phil. Trans.*, vol. xcviii.—Observations of a comet, made with a view to investigate its magni'ude and the nature of its illumination. To which is added an account of a new irregularity lately perceived in the apparent figure of the planet Saturn.

1809. *Phil. Trans.*, vol. xcix.—Continuation of experiments for investigating the cause of colored concentric rings and other appearances of a similar nature.

1810. *Phil. Trans.*, vol. c.—Supplement to the first and second part of the paper of experiments for investigating the cause of colored concentric rings between object-glasses, and other appearances of a similar nature.

1811. *Phil. Trans.*, vol. ci.—Astronomical observations relating to the construction of the heavens, arranged for the purpose of a critical examination, the result of which appears to throw some new light upon the organization of the celestial bodies.

1812. *Phil. Trans.*, vol. cii.—Observations of a comet, with remarks on the construction of its different parts.—Observations of a second comet, with remarks on its construction.

1814. *Phil. Trans.*, vol. civ.—Astronomical observations relating to the sidereal part of the heavens, and its connection with the nebulous part; arranged for the purpose of a critical examination.

1815. *Phil. Trans.*, vol. cv.—A series of observations of the satellites of the Georgian Planet, including a passage through the node of their orbits; with an introductory account of the telescopic apparatus that has been used on this occasion, and a final exposition of some calculated particulars deduced from the observations.

1817. *Phil. Trans.*, vol. cvii.—Astronomical observations and experiments tending to investigate the local arrangement of the celestial bodies in space, and to determine the extent and condition of the Milky Way.

1818. *Phil. Trans.*, vol. cviii.—Astronomical observations and experiments selected

for the purpose of ascertaining the relative distances of clusters of stars, and of investigating how far the power of telescopes may be expected to reach into space, when directed to ambiguous celestial objects.

1822. *Memoirs of the Astronomical Society of London.*—On the positions of 145 new double stars.

The chronological and detailed analysis of so many labors would involve numerous repetitions. A systematic order will be preferable, since it more distinctly fixes the eminent place that Herschel will never cease to occupy in the small group of contemporary men of genius, while his name will reëcho to the most distant posterity. The variety and splendor of Herschel's labors vie with their extent. The more we study them the more we must admire them. It is with great men as it is with great movements in the arts: we cannot understand them without studying them from various points of view.

Let us here again make a general reflection. The memoirs of Herschel are, for the greater part, pure and simple extracts from his inexhaustible journals of observations at Slough, accompanied by brief remarks. Such a table would not suit historical details. In these respects the author has left almost everything to his biographers to do for him. And they must impose on themselves the task of assigning to the great astronomer's predecessors the portion that legitimately belongs to them out of the mass of discoveries which the public, we must say, are in the habit of erroneously referring too exclusively to Herschel.

At one time I thought of adding a note to the analysis of each of the illustrious observer's memoirs, containing a detailed account of the improvements or corrections to which the progressive march of science has led. But in order to avoid an exorbitant length in this biography, I have been obliged to give up my project. In general, I shall content myself with pointing out what belongs to Herschel, referring to Arago's Treatise on Popular Astronomy for the historical details. The life of Herschel had the rare advantage of forming an epoch in an extensive branch of astronomy; it would require us almost to write a special treatise on astronomy to show thoroughly the importance of all the researches that are due to him.

IMPROVEMENTS IN THE MEANS OF OBSERVATION.

The improvements that Herschel made in the construction and management of telescopes have contributed so directly to the discoveries with which that observer enriched astronomy that we cannot hesitate to bring them forward at once.

I find the following passage in a memoir by Lalande, printed in 1783, and forming part of the preface to Volume VIII of the Ephemerides of the Celestial Motions:

"Each time that Herschel undertakes to polish a mirror (of a telescope) he condemns himself to ten, or twelve, or even fourteen hours of constant work. He does not quit his workshop for a minute, not even to

eat, but receives from the hands of his sister that nourishment without which one could not undergo such prolonged fatigue. Nothing could induce Herschel to leave his work; for, according to him, if he did so it would be to spoil it."

The advantages that Herschel found in 1783, 1784, and 1785, in employing telescopes of twenty feet and with large apertures, made him desire to construct one much larger still. The expense would be considerable; the King provided for it. The work, begun about the close of 1785, was finished in August, 1789. This instrument had an iron cylindrical tube, thirty-nine feet four inches in length, and four feet ten inches in diameter. Such dimensions are enormous as compared with those of telescopes previously made. They will appear but small, however, to persons who have heard the report of a pretended ball given in the Slough telescope. The propagators of this popular rumor must have confounded the astronomer Herschel with the brewer Meux, and a cylinder in which a man of the smallest stature could scarcely stand upright, with divers wooden vats, as large as a house, in which beer is made in London.

Herschel's telescope, forty English feet* in length, allowed the realization of an idea, the advantages of which would not be sufficiently appreciated if I did not here recall to mind some facts.

In any telescope, whether refracting or reflecting, there are two principal parts: the part that forms the aerial images of the distant objects, and the small lens by the aid of which these images are magnified just as if they consisted of radiating matter. When the image is produced by means of a lenticular glass, the place it occupies will be found in the prolongation of the line that extends from the object to the center of the lens. The astronomer, furnished with an eye-piece and wishing to examine that image, must necessarily place himself *beyond* the point where the rays that form it have crossed each other; *beyond*, let us carefully remark, means *farther off* from the object-glass. The observer's head, cannot then interfere with the formation or the brightness of the image, however small may be the distance from which he may have to study it. But it is no longer thus with the image formed by means of reflection. For the image is now placed between the object and the reflecting mirror, and when the astronomer approaches in order to examine it, he inevitably intercepts, if not the totality, at least a very considerable portion, of the luminous rays, which would otherwise have contributed to give it great distinctness. It will now be understood why, in optical instruments where the images of distant objects are formed by the reflection of light, it has been necessary to carry the images, by the aid of a second reflection, out of the tube that contains and sustains the

* Conforming to general usage, and to Sir W. Herschel himself, we shall allude to this instrument as the *forty-foot* telescope, though M. Arago adheres to thirty-nine feet and drops the inches, probably because the Parisian foot is rather longer than the English.—TRANSLATOR'S NOTE.

principal mirror. When the small mirror on the surface of which the second reflection is effected is plane and inclined at an angle of 45° to the axis of the telescope; when the image is reflected laterally through an opening made near the edge of the tube and furnished with an eye-piece; when, in a word, the astronomer looks definitively in a direction perpendicular to the line described by the luminous rays coming from the object and falling on the center of the great mirror, then the telescope is called *Newtonian*. But in the *Gregorian* telescope the image formed by the principal mirror falls on a second mirror, which is very small, slightly curved, and parallel to the first. The small mirror reflects the first image and throws it beyond the large mirror, through an opening made in the middle of that mirror.

Both in the one and in the other of these two telescopes, the small mirror interposed between the object and the great mirror forms relative to the latter a sort of screen which prevents its entire surface from contributing toward forming the image. The small mirror also, in regard to intensity, gives some trouble.

Let us suppose, in order to clear up our ideas, that the material of which the two mirrors are made reflects only half of the incident light. In the course of the first reflection, the immense number of rays that the aperture of the telescope had received may be considered as reduced to half. Nor is the diminution less on the small mirror. Now, half of a half is a quarter. Therefore the instrument will send to the eye of the observer only a quarter of the incident light that its aperture had received If these two causes of diminished light did not exist in a refracting telescope, it would give, under parity of dimensions, four times more * light than a Newtonian or Gregorian telescope gives.

Herschel did away with the small mirror in his large telescope by placing the large mirror obliquely in the tube which causes the images to be formed, not in the axis of the tube, but very near the circumference or edge of the outer mouth, as we may call it. The observer might therefore look at them directly merely by means of an eye-glass. A small portion of the astronomer's head, it is true, encroaches on the tube, forms a screen, and interrupts some incident rays. Still, in a large telescope, this loss does not amount to half as much as it would inevitably do if the small mirror were there.

Those telescopes in which the observer, standing at the anterior extremity of the tube, looks directly into it, turning his back to the objects, were called by Herschel *front-view telescopes*. In Volume LXXVI of the Philosophical Transactions, he says that the idea of this construction occurred to him in 1776, and that he then applied it unsuccessfully to a ten-foot telescope; that during the year 1784 he again made a fruitless trial of it in a twenty-foot telescope. Yet I find that on the 7th of September, 1784, he recurred to *a front view* in observing some nebulæ and groups of stars. However discordant these dates may be, we cannot

* It would be more correct to say four times as much light.—TRANSLATOR.

without injustice neglect to remark that a front-view telescope was already described in 1732, in Volume VI of the collection entitled "Machines and Inventions approved by the Academy of Sciences." The author of this innovation is Jacques Lemaire, who has been unduly confounded with the English Jesuit, Christopher Maire, assistant to Boscovitch, in measuring the meridian comprised between Rome and Rimini. Jacques Lemaire, having only telescopes of moderate dimensions in view, was obliged, in order not to sacrifice any of the light, to place the great mirror so obliquely that the image formed by its surface should fall entirely outside the tube of the instrument. So great a degree of inclination would certainly distort the image. The *front-view* construction is admissible only in very large telescopes.

I find in the Transactions for 1803 that, in solar observations, Herschel sometimes employed telescopes, the great mirror of which was made of glass. It was with a telescope of this kind, seven feet long, and six inches and three-tenths in diameter, that he observed the transit of Mercury on the 9th of November, 1802.

Practical astronomers know how much the mounting of a telescope contributes to produce correct observations. The difficulty of a solid yet very movable mounting increases rapidly with the dimensions and weight of an instrument. We may then conceive that Herschel had to surmount many obstacles in mounting a telescope suitably of which the mirror alone weighed upward of 1,000 kilograms, (a ton.) But he solved this problem to his entire satisfaction by the aid of a combination of spars, pulleys, and ropes, of which a correct idea may be formed by referring to the wood-cut given in Arago's Treatise on Popular Astronomy, (Vol. I.) This apparatus, and the different stands that Herschel devised for telescopes of smaller dimensions, assign to that illustrious observer a distinguished place among the most ingenious mechanics of our age.

The public in general—I may even say the greater part of astronomers—know not what was the effect that the great forty-foot telescope had in the labors and discoveries of Herschel. Still, we are not less mistaken when we suppose that the observer of Slough always used this telescope than in imagining, with Baron von Zach, (see *Monatliche Correspondenz*, January, 1802) that the colossal instrument was of no use at all; that it did not contribute to any new discovery; that it must be considered as a mere object of curiosity. These assertions are distinctly contradicted by Herschel's own words. In the volume of Philosophical Transactions for the year 1795 (p. 350) I read, for example: "On the 28th of August, 1789, having directed my telescope (of forty feet) to the heavens, I discovered the sixth satellite of Saturn, and I perceived the spots on that planet better than I had been able to do before." (See also relative to this sixth satellite the Philosophical Transactions for 1790, p. 10.) In that same volume of 1790 (p. 11) I find: "The great light of my forty-foot telescope was so useful that on the 17th of September, 1789, I re-

marked the seventh satellite, then situated at its greatest western elongation."

The 10th of October, 1791, Herschel saw the ring of Saturn and the fourth satellite, looking in at the mirror of his forty-foot telescope, with his naked eye, without any kind of eye-piece.

Let us acknowledge the true motives that prevented Herschel from oftener using his forty-foot telescope. Notwithstanding the excellence of the mechanism, the maneuvering of that instrument required the constant aid of two laborers, and that of another person charged with noting the time at the clock. Besides this, during nights when the variation of temperature was considerable, this telescope, on account of its great mass, was always behind the atmosphere in thermometric changes, giving rise to a difference of density in the air within and without the tube very injurious to the distinctness of the images.

Herschel found that in England there are not above a hundred hours in a year during which the heavens can be advantageously observed with a telescope of forty feet, furnished with a magnifying power of a thousand. This remark led the celebrated astronomer to the conclusion that to take a complete survey of the heavens with his large instrument, though each successive field should remain only for an instant under inspection, would not require less than eight hundred years.

He explains very clearly the rare occurrence of the circumstances in which it is possible to make good use of a telescope of forty feet, and of very large aperture.

A telescope does not magnify real objects only, but magnifies also the apparent irregularities arising from atmospheric refractions; now, all other things being equal, these irregularities of refraction must be so much the greater, so much the more frequent, as the stratum of air is thicker through which the rays have passed in going to form the image.

Astronomers expressed extreme surprise when, in 1782, they learned that Herschel had applied linear magnifying powers of a thousand, of twelve hundred, of two thousand two hundred, of two thousand six hundred, and even of six thousand times, to a reflecting telescope of seven feet in length. The Royal Society of London participated in this surprise, and officially requested Herschel to give publicity to the means he had adopted for using such amounts of magnifying power in his telescopes. Such was the object of a memoir that he inserted in Volume LXXII of the Philosophical Transactions; and it dissipated all doubts. No one will be surprised that magnifying powers, which it would seem ought to have shown the lunar mountains as the chain of Mont Blanc is seen from Maçon, from Lyons, and even from Geneva, were not easily believed in. They did not know that Herschel had never used magnifying powers of three thousand and six thousand times, except in observing brilliant stars; they had not remembered that light reflected by planetary bodies is too feeble to continue distinct

ınder the same degree of magnifying power as the direct light of the ixed stars does.

Opticians had given up, more from theory than from careful experiaents, attempting high magnifying powers, even for reflecting telescopes. 'hey thought that the image of a small circle cannot be distinct, cannot e sharp at the edges, unless the pencil of rays coming from the object a nearly parallel lines, and which enters the eye after having passed hrough the eye-piece, be sufficiently broad. This being once granted, he inference followed that an image ceases to be well defined when it oes not strike at least two of the nervous filaments of the retina with hich that organ is supposed to be overspread. These gratuitous onditions, grafted on each other, vanished in presence of Herschel's bservations. After having put himself on his guard against the effects f diffraction—that is to say, against the scattering that light undergoes hen it passes the terminal angles of bodies—the illustrious astronomer roved, in 1786, that objects can be seen well defined by means of penls of light whose diameter does not equal five-tenths of a millimeter.

Herschel considered the almost unanimous opinion of the double-lens ye-piece being preferable to the single-lens eye-piece as a very injurious rejudice to science, since experience proved to him, notwithstanding all ieoretic deductions, that, with equal magnifying powers, in reflecting lescopes, at least (and this restriction is of some consequence), the nages were brighter and better defined with single than with double ye-pieces. On one occasion this latter eye-piece could not show him ie bands of Saturn, while by the aid of a single lens they were perfectly isible. Herschel said: "The double eye-piece must be left to amateurs, nd to those who, for some particular object, require a large field of vis-n." (Philosophical Transactions, 1782, pp. 94 and 95.)

It is not only relative to the comparative merit of single or double ye-pieces that Herschel differs in opinion from opticians generally. le thinks, moreover, that he has proved, by decisive experiments, that oncave eye-pieces (like that used by Galileo) surpass the convex eyeiece, both as regards clearness and definition.

Herschel assigns the date of 1776 to the experiments which he made o decide this question. (Philosophical Transactions, year 1815, p. 297.) 'lano-concave and double-concave lenses produced similar effects. In 'hat did these lenses differ from the double-convex lenses? In one articular only: the latter received the rays reflected by the large mir-or of the telescope after their union at the focus, whereas the concave enses received the same rays before that union. When the observer iade use of a convex lens, the rays that went to the back of the eye to orm an image on the retina had previously crossed each other in the air, ut no crossing of this kind took place when the observer used a conave lens. Holding the double advantage of this latter sort of lens ver the other as quite proved, one would be inclined, like Herschel,

to admit "that a certain mechanical effect, injurious to clearness and definition, would accompany the focal crossing of the rays of light."*

This idea of the crossing of the rays suggested an experiment, the result of which deserves to be recorded. A telescope of ten English feet was directed toward an advertisement covered with very small printing, and placed at a sufficient distance. The convex lens of the eye-piece was carried, not by a tube, properly so called, but by four fine rigid wires, placed at right angles; this arrangement left the focus open in almost every direction. A concave mirror was then placed so that it threw a very condensed image of the sun laterally on the very spot where the image of the advertisement was formed. The solar rays, after having crossed each other, finding nothing on their route, went on and lost themselves in space. A screen, however, allowed the rays to be intercepted at will before they united. This done, having applied the eye to the eye-piece, and directed all his attention to the telescopic image of the advertisement, Herschel did not perceive that the taking away and then replacing the screen made the least change in the brightness or definition of the letters. It was, therefore, of no consequence, in this instance as well as in the other, whether the immense quantity of solar rays crossed each other at the very place where, *in another direction*, the rays united that formed the image of the letters. I have marked in Italics the words that especially show in what this curious experiment differs from the previous experiments, and yet does not entirely contradict them. In this instance, the rays were of different origin, those coming from the advertisement and those from the sun crossed each other, respectively, in an almost rectangular direction; while in the comparative examination of the stars with convex and with concave eye-pieces, the rays that seemed to have a mutual influence had a common origin, and crossed each other at very acute angles. There seems to be nothing, then, in the results at which we need to be much surprised.

Herschel increased the catalogue, already so extensive, of the mysteries of vision, when he explained in what manner we must endeavor to distinguish separately the two members of certain double stars very close to each other. He said, "If you wish to assure yourself that η Coronæ is a double star, first direct your telescope to α Geminorum, to ζ Aquarii, to μ Draconis, to ρ Herculis, to α Piscium, to ε Lyræ. Look at those stars for a long time, so as to acquire the habit of observing such objects; then pass on to ξ Ursæ majoris, where the closeness of the two members is still greater. In a third essay select ι Bootis,

* On comparing the Cassegrain telescopes, with a small convex mirror, to the Gregorian telescopes, with a small concave mirror, Captain Kater found that the former, in which the luminous rays do not cross each other before falling on the small mirror, possess, as to intensity, a marked advantage over the latter, in which this crossing takes place.

(marked 44 by Flamsteed and *i* in Harris's maps,)* the star that precedes *a* Orionis *n* of the same constellation, and you will then be prepared for the more difficult observation of η Coronæ. Indeed, η Coronæ is a sort of miniature of *i* Bootis, which may itself be considered as a miniature of *a* Geminorum." (Philosophical Transactions, 1782, p. 100.)

As soon as Piazzi, Olbers, and Harding had discovered three of the numerous telescopic planets now known, Herschel proposed to himself to determine their real magnitudes; but telescopes not having then been applied to the measurement of excessively small angles, it became requisite, in order to avoid any illusion, to try some experiments adapted to giving a scale of the powers of those instruments. Of the labor of our indefatigable astronomer in this line, I am going to give a condensed account.

The author relates first, that in 1774 he endeavored to ascertain experimentally, with the naked eye, and at the distance of distinct vision, what angle a circle must subtend to be distinguished by its form from a square of similar dimensions. The angle was never smaller than 2′ 17″; therefore, at its maximum it was about one-fourteenth of the angle subtended by the diameter of the moon.

Herschel did not say of what nature the circles and squares of paper were that he used, nor on what background they were projected. It is an omission to be regretted, since in those phenomena the intensity of light must be an important feature. However it may have been, the scrupulous observer, not daring to extend to telescopic vision what he had discovered relative to vision with the naked eye, he undertook to do away with all doubt by direct observations.

On examining some heads of pins, placed at a distance in the open air, with a three-foot telescope, Herschel could easily discern that those bodies were round when the subtended angles became, after being magnified, 2′ 19″. This is almost exactly the result obtained with the naked eye.

When the globules were darker—when, instead of pins' heads, small globules of sealing-wax were used—their spherical form did not begin to be distinctly visible till the moment when the subtended magnified angles—that is, the moment when the natural angle multiplied by the magnifying power—amounted to five minutes.

In a subsequent series of experiments, some globules of silver, placed very far from the observer, allowed their globular form to be perceived, even when the magnified angle remained below two minutes.

* In the selection of *i* Bootis as a test, Arago has taken the precaution of giving its corresponding denomination in other catalogues, and Bailey appends the following note, No. 2062, to 44 Bootis: "In the British Catalogue this star is not denoted by any letter, but Bayer calls it *i*, and on referring to the earliest MS. catalogue in MSS. Vol. XXV, I find it is there so designated; I have therefore restored the letter." (See Bailey's edition of Flamsteed's British Catalogue of Stars, 1835.) The distance between the two members of this double star is 3″.7, and position 23°.5. (See Bedford Cycle.)—TRANSLATOR.

Under equality of subtended angle, then, the telescopic vision with strong magnifying powers showed itself superior to the naked-eye vision. This result is not unimportant.

If we take notice of the magnifying powers used by Herschel in these laborious researches—powers that often exceeded five hundred times—it will appear to be established that the telescopes possessed by modern astronomers may serve to verify the round form of distant objects, the form of celestial bodies, even when the diameters of those bodies do not subtend naturally, to the naked eye, angles of above three-tenths of a second; and 500 multiplied by three-tenths of a second give 2′ 30″.

Much still remained to be learned in regard to refracting telescopes; even when they already served to reveal brilliant astronomical phenomena; the result was due rather to chance than to definite theory. Their theory, as far as it depended on geometry and optics, had made rapid progress. These two early phases of the problem leave but little more to be wished for; it is not so with a third phase, hitherto a good deal neglected, connected with physiology, and with the action of light on the nervous system. Therefore, we should search in vain in old treatises on optics and on astronomy for a strict and complete discussion on the comparative effect that the size and intensity of the images that the magnifying power and the aperture of a telescope may have, by night and by day, on the visibility of the faintest stars. This lacuna Herschel tried to fill up in 1799; such was the aim of the memoir entitled "On the Space-penetrating Power of Telescopes."

This memoir contains excellent things; still it is far from exhausting the subject. The author, for instance, entirely overlooks the observations made by day. I also find that the hypothetical part of the discussion is not perhaps as distinctly separated from the rigorous part as it might be; that doubtful numbers, though given with a degree of precision down to the smallest decimals, do not contrast well as terms of comparison with those which, on the contrary, rest on observations bearing mathematical evidence of correctness.

Whatever may be thought of these remarks, the astronomer or the physicist who would like again to undertake the question of visibility with telescopes will find some important facts in Herschel's memoir, and some ingenious observations, well adapted to serve them as guides.

LABORS IN SIDEREAL ASTRONOMY.

The curious phenomenon of a periodical change of intensity in certain stars very early excited the earnest attention of Herschel. The first memoir by that illustrious observer, presented to the Royal Society of London, and inserted in the Philosophical Transactions, treats especially of the changes of intensity of the star *o* in the neck of the Whale.

This memoir was dated from Bath, May, 1780. Eleven years afterward, in the month of December, 1791, Herschel communicated a second time to that celebrated English society the observations that he had made by

occasionally directing his telescopes to this mysterious star. At both those epochs the observer's attention was chiefly directed to the absolute values of the *maxima* and *minima* of intensity.

The changeable star in the Whale was not the only periodical star with which Herschel occupied himself. His observations of 1795 and of 1796 proved that α Herculis also belongs to the category of variable stars, and that the time requisite for the accomplishment of all the changes of intensity, and for the star's return to any given state, was sixty days and a quarter. When Herschel obtained this result, about ten changeable stars were already known; but they were all either of very long or very short periods. The illustrious astronomer considered that by introducing between two groups that exhibited very short and very long periods a star of somewhat intermediate conditions—for instance, one requiring sixty days to accomplish all its variations of intensity—he had advanced the theory of these phenomena by an essential step; the theory at least that attributes all to a movement of rotation which the stars may undergo round their centers.

Sir William Herschel's catalogues of double stars offer a considerable number to which he ascribes a decided green or blue tint. In binary combinations, when the small star appears very blue or very green, the large one is usually yellow or red. It does not appear that the great astronomer took sufficient interest in this circumstance. I do not find, indeed, that the almost constant association of two complementary colors (of yellow and blue, or of red and green) ever led him to suspect that one of those colors might not have anything real in it, that it often might be a mere illusion, a mere result of contrast. It was only in 1825 that I showed that there are stars whose contrast really explains their apparent color; but I have proved besides that blue is incontestably the color of certain insulated stars, or stars that have only white ones, or other blue ones, in their vicinity. Red is the only color that the ancients ever distinguished from white in their catalogues.

Herschel also endeavored to introduce numbers in the classification of stars as to magnitude; he has endeavored, by means of these, to show the comparative intensity of a star of the first magnitude with one of second, or one of third magnitude, &c.

In one of the earliest of Herschel's memoirs, we find that the apparent sidereal diameters are proved to be for the greater part factitious, even when the best telescopes are used. Diameters estimated by seconds—that is to say, reduced according to the magnifying power—diminish in certainty as the magnifying power is increased. These results are of the greatest importance.

In the course of his investigation of sidereal parallax, though without finding it, Herschel made an important discovery—that of the proper motion of our system. To show distinctly the direction of the motion of the solar system, not only was a displacement of the sidereal perspective required, but profound mathematical knowledge, and a peculiar tact.

This peculiar tact Herschel possessed in an eminent degree. Moreover, the result deduced from the very small number of proper motions known at the beginning of 1783, has been found almost to agree with that found recently by our best astronomers, with the application of subtile analytical formulæ, to a considerable number of exact observations.

The proper motions of the stars have been known for more than a century, and even Fontenelle used to say, in 1738, that the sun has probably a similar motion. The idea of partly attributing the displacement of the stars to a motion of the sun had suggested itself to Bradley and to Mayer. Lambert especially had been very explicit on the subject. Until then, however, there were only conjectures and mere probabilities. Herschel passed these limits. He proved that the sun himself positively moves, and that in this respect that immense and dazzling body must also be classed among the stars; that the apparently inextricable irregularities of numerous sidereal proper motions arise in great measure from the displacement of the solar system; that, in short, the point of space toward which we are annually advancing is situated in the constellation of Hercules.

These are magnificent results. The discovery of the proper motion of our system will always be accounted among Herschel's highest claims to glory, even after the mention that my duty as historian has obliged me to make of the anterior conjectures of Fontenelle, of Bradley, of Mayer, and of Lambert.

By the side of this great discovery we should place another, that seems likely to be expanded in future. The results which it allows us to hope for will be of extreme importance. The discovery here alluded to was announced to the learned world in 1803; it is that of the reciprocal dependence of several stars, connected the one with the other, as the several planets and their satellites of our system are with the sun.

Let us to these immortal labors add the ingenious ideas that we owe to Herschel on the nebulæ, on the constitution of the Milky Way, on the universe as a whole—ideas which almost by themselves constitute the actual history of the formation of the worlds—and we cannot have too deep a reverence for that powerful genius that notwithstanding the play of an ardent imagination scarcely ever erred.

LABORS RELATIVE TO THE SOLAR SYSTEM.

Herschel devoted much time to the sun, but only relative to its physical constitution. The observations that he made on this subject, and the consequences that he deduced from them, equal in interest the most ingenious discoveries for which the sciences are indebted to him.

In his important memoir in 1795, the great astronomer declares himself convinced that the substance by the intermediation of which the sun shines cannot be either a liquid or an elastic fluid. It must be analogous to our clouds, and float in the transparent atmosphere of that body. The sun has, according to him, two atmospheres, endowed with

motions quite independent of each other. An elastic fluid of an unknown nature is being constantly formed on the dark surface of the sun, and rising up, on account of its specific lightness, it forms the *pores* in the stratum of reflecting clouds; then, combining with other gases, it produces the striæ in the region of luminous clouds. When the ascending currents are powerful, they give rise to the *nuclei*, to *penumbræ*, and the *faculæ*. If this explanation of the formation of solar spots is well founded, we must expect to find that the sun does not constantly emit equal quantities of light and heat. Recent observations have verified this conclusion. But large nuclei, large penumbræ, striæ, faculæ, do they indicate an abundant, luminous, and calorific emission, as Herschel supposed? That would be the result of his hypothesis on the existence of very active ascending currents, but direct experience seems to contradict it.

The following is the way in which a learned physicist, Sir David Brewster, appreciates this view of Herschel's: "It is not conceivable that luminous clouds, ceding to the lightest impulses and in a state of constant change, can be the source of the sun's devouring flame and of the dazzling light which it emits; nor can we admit, besides, that the feeble barrier formed by planetary clouds would shelter the objects that it might cover from the destructive effects of the superior elements."

Sir David Brewster imagines that the non-luminous rays of caloric, which form a constituent part of the solar light, are emitted by the dark nucleus of the sun; while the visible colored rays proceed from the luminous matter by which the nucleus is surrounded. "From thence," he says, "proceeds the reason of light and heat always appearing in a state of combination; the one emanation cannot be obtained without the other. With this hypothesis we could readily explain why it is hottest when there are most spots, because the heat of the nucleus would then reach us without having been weakened by the atmosphere that it usually has to traverse." But it is far from being an ascertained fact that we experience increased heat during the apparition of solar spots; the inverse phenomenon is more probably true.

Herschel also studied the physical constitution of the moon. In 1780, he sought to measure the height of the mountains of our satellite. The conclusion that he drew from his observations was, that few of the lunar mountains exceed 800 meters, (or 2,600 feet.) More recent selenographic observations give conclusions different from this. There is reason to remark, on this occasion, how much the result presented by Herschel differs from any tendency to the extraordinary or the gigantic, that has been so unjustly assigned as the characteristic of the illustrious astronomer.

At the close of 1787, Herschel presented a memoir to the Royal Society, the title of which must have made a strong impression on the popular mind. The author therein relates that, on the 19th of April, 1787, he had observed in the non-illuminated part of the moon—that is, in

the then dark portion—three volcanoes in a state of ignition. Two of these volcanoes appeared to be on the decline, the other appeared to be active. Such was his conviction of the reality of the phenomenon, that the next morning he made the following record: "The volcano burns with more violence than last night." The real diameter of the volcanic light was 5,000 meters, (16,400 English feet.) Its intensity appeared very superior to that of the nucleus of a comet then in apparition. He further added: "The objects situated near the crater are feebly illuminated by the light that emanates from it;" and concludes thus: "In short, this eruption very much resembles the one I witnessed on the 4th of May, 1783."

How happens it, after such exact observations, that few astronomers now admit the existence of active volcanoes in the moon? I will explain this singularity in a few words.

The various parts of our satellite do not all equally reflect light. Here, it may depend on the form, elsewhere, on the nature of the materials. Those who have examined the moon with telescopes know how very considerable the difference arising from these two causes may be, how much brighter one point of the moon sometimes is than those around it. Now, it is quite evident that the relations of intensity between the faint parts and the brilliant ones must continue to exist, whatever be the origin of the illuminating light. In the portion of the lunar globe that is illuminated by the sun there are, everyone knows, some points, the brightness of which is extraordinary compared to those around them; those same points, when they are seen in that portion of the moon that is only lighted by the earth, or in the ash-colored part, will still predominate over the neighboring regions by their comparative intensity. Thus we may explain the observations of the Slough astronomer, without recurring to volcanoes. While the observer was studying in the non-illuminated portion of the moon the supposed volcano of the 20th of April, 1787, his nine-foot telescope showed him in truth, by the aid of the secondary rays proceeding from the earth, even the darkest spots.

Herschel did not recur to the discussion of the supposed actually burning lunar volcanoes until 1791. In the volume of the Philosophical Transactions for 1792, he relates that in directing a twenty-foot telescope, magnifying three hundred and sixty times, to the entirely eclipsed moon, on the 22d of October, 1790, there were visible, over the whole face of the satellite, about a hundred and fifty very luminous red points. The author declares that he will observe the greatest reserve relative to the nature of all these points, their great brightness, and their remarkable color.

Yet is not red the usual color of the moon when eclipsed, and when it has not entirely disappeared? Could the solar rays reaching our satellite by the effect of refraction, and after an absorption experienced in the lowest strata of the terrestrial atmosphere, receive any other tint? Are there not in the moon, when freely illuminated, and opposite to the

sun, from one to two hundred little points, remarkable by the brightness of their light? Would it be possible for these little points not to be also distinguishable in the moon when it receives only the portion of solar light which is refracted and colored by our atmosphere?

Herschel was more successful in his remarks on the absence of a lunar atmosphere. During the solar eclipse of the 5th September, 1793, the illustrious astronomer particularly directed his attention to the shape of the acute horn resulting from the intersection of the limbs of the moon and of the sun. He deduced from his observation that if toward the point of the horn there had been a deviation of only one second, occasioned by the refraction of the solar light in the lunar atmosphere, it would not have escaped him.

He also made the planets the object of numerous researches. Mercury was the one to which he gave least attention; he found its disk perfectly round on observing it during its projection—that is to say, in astronomical language, during its transit over the sun, on the 9th of November, 1802. He sought to determine the time of the rotation of Venus as early as 1777. He published two memoirs relative to Mars, the one in 1781, the other in 1784, and we owe to him the discovery of its being flattened at the poles. After the discovery of the small planets, Ceres, Pallas, Juno, and Vesta, by Piazzi, Olbers, and Harding, Herschel applied himself to measuring their angular diameters. He concluded from his researches that those four new bodies did not deserve the name of planets, and he proposed to call them asteroids. This epithet was subsequently adopted, though bitterly criticised by a historian of the Royal Society of London, Dr. Thomson, who went so far as to suggest that the learned astronomer "had wished to deprive the first observers of those bodies of all idea of rating themselves as high as himself in the scale of astronomical discoverers." I should require nothing further to annihilate such an imputation than to put it by the side of the following passage, extracted from a memoir by this celebrated astronomer, published in the Philosophical Transactions for the year 1805: "The specific difference existing between planets and asteroids appears now, by the addition of a third individual of the latter species, to be more completely established, and that circumstance, in my opinion, has added more to the *ornament* of our system than the discovery of a new planet could have done."

Although much has not resulted from Herschel's investigations in regard to the physical constitution of Jupiter, astronomy is indebted to him for several important results relative to the time of that planet's rotation. He also made numerous observations on the distances and comparative magnitude of its satellites.

The compression of Saturn, the duration of its rotation, the physical constitution of this planet and that of its ring, were, on the part of Herschel, the object of numerous researches which have much contributed

to the progress of planetary astronomy. But on this subject two important discoveries especially added new glory to his name.

Of the five known satellites of Saturn at the close of the seventeenth century, Huygens had discovered the fourth; Cassini the others.

The field seemed to be exhausted, when news from Slough announced that this was a mistake.

On the 28th of August, 1789, the great forty-foot telescope revealed to Herschel a satellite still nearer to the ring than the other five already observed. According to the principles of the nomenclature previously adopted, the small body of the 28th August ought to have been called the first satellite of Saturn; the numbers indicating the places of the other five would then have been each increased by a unity. But the fear of introducing confusion into science by these continual changes of denomination induced a preference for calling the new satellite the sixth.

Thanks to the prodigious powers of the forty-foot telescope, a last satellite, the seventh, showed itself on the 17th of September, 1789, between the sixth and the ring.

This seventh satellite is extremely faint. Herschel, however, succeeded in seeing it whenever circumstances were very favorable, even by the aid of the twenty-foot telescope.

The discovery of the planet Uranus, and the detection of its satellites, will always occupy one of the highest places among those by which modern astronomy is honored.

On the 13th of March, 1781, between ten and eleven o'clock at night, while Herschel was examining the small stars near H Geminorum with a seven-foot telescope, bearing a magnifying power of two hundred and twenty-seven times, one of these stars seemed to have an unusual diameter, and it was, therefore, thought to be a comet. It was under this denomination that it was discussed at the Royal Society of London. But the researches of Herschel and of Laplace showed later that the orbit of the new body was nearly circular, and Uranus was consequently elevated to the rank of a planet.

The immense distance of Uranus, its small angular diameter, and the feebleness of its light, scarcely allowed the hope that, if that body had satellites, they could be perceived from the earth. Herschel was not a man to be deterred by such discouraging conjectures. Therefore, since powerful telescopes of the ordinary construction—that is to say, with two mirrors conjugated—had not enabled him to discover anything, he substituted, in the beginning of January, 1787, *front-view* telescopes—that is, telescopes throwing much more light on the objects, the small mirror being then suppressed, and with it one of the causes of loss of light is got rid of.

By this means, with patient labor and observations requiring a rare perseverance, Herschel made (from the 11th of January, 1787, to the 28th of February, 1794) the discovery of the six satellites of his planet, and thus completed the system of worlds that belongs entirely to himself.

There are several of Herschel's memoirs on comets. In analyzing hem we shall see that this acute observer could not touch anything ;ithout making further discoveries in regard to it.

He applied some of his fine instruments to the study of the physical onstitution of a comet discovered by Mr. Pigott, on the 28th September, 807. The nucleus was round and well-determined. Some measures taken n the day when the nucleus subtended only an angle of a single second ;ave as its real diameter $\frac{6}{100}$ of the diameter of the earth.

Herschel saw no phase at an epoch when only $\frac{7}{10}$ of the nucleus could ›e illuminated by the sun. The nucleus then must shine by its own ight.

This is a legitimate inference in the opinion of every one who will llow, on the one hand, that the nucleus is a solid body, and on the other, hat it would have been possible to observe a phase of $\frac{8}{10}$ on a disk whose ıpparent total diameter did not exceed one or two seconds of a degree.

Very small stars seemed to grow much paler when they were seen hrough the coma or through the tail of the comet.

This faintness may have only been apparent, and might arise from he circumstance of the stars being then projected on a luminous back- ground. Such is, indeed, the explanation adopted by Herschel. A gaseous medium, capable of reflecting sufficient solar light to efface that of some stars, would appear to him to possess in each stratum a sensi- ble quantity of matter, and to be, for that reason, a cause of real dimi- nution of the light transmitted, though nothing reveals the existence of such a cause.

This argument, offered by Herschel in favor of the system which transforms comets into self-luminous bodies, has not, as we may perceive, much force. I might venture to say as much of several other remarks by this great observer. He tells us that the comet was distinctly visible in the telescope on the 21st of February, 1808; now, on that day, its dis- tance from the sun amounted to 2.7 times the mean radius of the terres- trial orbit; its distance from the observer was 2.9: "What probability would there be that rays going to such distances, from the sun to the comet, could, after their reflection, be seen by an eye nearly three times more distant from the comet than from the sun?"

It is only numerical determinations that could give value to such an argument. By satisfying himself with vague reasoning, Herschel did not even perceive that he was committing a great mistake by making the comet's distance from the observer appear to be an element of visi- bility. If the comet be self-luminous, its intrinsic splendor (its bright- ness for unity of surface) will remain constant at any distance, as long as the subtended angle remains sensible. If the body shines by bor- rowed light, its brightness will vary only according to its change of dis- tance from the sun; nor will the distance of the observer occasion any change in the visibility; always, let it be understood, with the restriction that the apparent diameter shall not be diminished below certain limits.

Herschel finished his observations of a comet that was visible in January, 1807, with the following remark:

"Of the sixteen telescopic comets that I have examined, fourteen had no solid body visible at their center; the other two exhibited a central light, very ill-defined, that might be termed a nucleus, but a light that certainly could not deserve the name of a disk."

The beautiful comet of 1811 became the object of his conscientious labor. With large telescopes he saw, in the midst of the gaseous head, a reddish body of planetary appearance, which bore strong magnifying powers, and showed no sign of phase. Hence Herschel concluded that it was self-luminous. Yet if we reflect that the planetary body under consideration was not a second in diameter, the absence of a phase does not appear a conclusive argument.

The light of the head had a bluish-green tint. Was this a real tint, or did the central reddish body, only through contrast, cause the surrounding vapor to appear colored? Herschel did not examine the question from this point of view.

The head of the comet appeared to be enveloped at a certain distance, on the side toward the sun, by a brilliant narrow zone, embracing about a semicircle, and of a yellowish color. From the two extremities of the semicircle there arose, toward the region away from the sun, two long luminous streaks which limited the tail. Between the brilliant circular semi-ring and the head, the cometary substance seemed dark, very rare, and very diaphanous.

The luminous semi-ring always presented similar appearances in all the positions of the comet; it was not then possible to attribute to it really the annular form—the shape of Saturn's ring, for example. Herschel sought whether a spherical semi-envelope of luminous matter, and yet diaphanous, would not lead to a natural explanation of the phenomenon. In this hypothesis, the visual rays, which on the 6th of October, 1811, traversed a thickness of matter of about 399,000 kilometers, (248,000 English miles,) while the visual rays near the head of the comet did not meet above 80,000 kilometers (50,000 miles) of matter. As the brightness must be proportional to the quantity of matter traversed, there could not fail to be an appearance around the comet of a semi-ring five times more luminous than the central regions. This semi-ring, then, was an effect of projection, and it has revealed a circumstance to us truly remarkable in the physical constitution of comets.

The two luminous streaks that outlined the tail at its two limits may be explained in a similar manner; the tail was not flat, as it appeared to be; it had the form of a conoid, with its sides of a certain thickness. The visual lines which traversed those sides almost tangentially evidently met much more matter than the visual lines passing across. This maximum of matter could not fail of being represented by a maximum of light.

The luminous semi-ring appeared one day to be suspended in the

diaphanous atmosphere by which the head of the comet was surrounded, at a distance of 518,000 kilometers (322,000 English miles) from the nucleus.

This distance was not constant. The matter of the semi-annular envelope seemed even to be precipitated by slow degrees through the diaphanous atmosphere; finally it reached the nucleus; the earlier appearances vanished; the comet was reduced to a globular nebula.

During its period of dissolution, the ring appeared sometimes to have several branches.

The luminous shreds of the tail seemed to undergo rapid, frequent, and considerable variations of length. Herschel discerned symptoms of a movement of rotation both in the comet and in its tail. This rotatory motion carried unequal shreds from the center toward the border, and reciprocally. On looking from time to time at the same region of the tail—at the border, for example—sensible changes of length must have been perceptible, which, however, had no real existence. Herschel thought, as I have already said, that the beautiful comet of 1811 and that of 1807 were self-luminous. The second comet of 1811 appeared to him to shine only by borrowed light. It must be acknowledged that these conjectures did not rest on anything demonstrative.

In attentively comparing the comet of 1807 with the beautiful comet of 1811, relative to the changes of distance from the sun, and the modifications resulting thence, Herschel put it beyond doubt that these modifications have something individual in them, something relative to a special state of the nebulous matter. On one celestial body the changes of distance produce an enormous effect; on another the modifications are insignificant.

OPTICAL LABORS.

I shall say very little as to the discoveries that Herschel made in physics, since every one is familiar with them. They are to be found in all elementary works, and are given in verbal instruction; they must be considered as the starting-point of a multitude of important labors with which the sciences have been enriched during later years.

The chief of these is that of the dark radiating heat which is found mixed with light.

In studying the phenomena, not with the eye, as Newton did, but with a thermometer, Herschel discovered that the solar spectrum is prolonged on the red side far beyond the visible limits. The thermometer sometimes rose higher in the dark region than in the midst of brilliant zones. The light of the sun, then, contains, besides the colored rays so well characterized by Newton, invisible rays, still less refrangible than the red, and whose warming power is very considerable. A world of discoveries has arisen from this fundamental fact.

The dark ray emanating from terrestrial objects more or less heated also became the subject of Herschel's investigations. His work contained

the germs of a large number of beautiful experiments more fully developed in our own day.

By successively placing the thermometer in all parts of the solar spectrum, he determined the illuminating powers of the various prismatic rays. The general result of these experiments may be thus enunciated: The illuminating power of the red rays is not very great; that of the orange rays surpasses it, and is in its turn surpassed by the power of the yellow rays. The maximum power of illumination is found between the brighest yellow and the palest green. The yellow and the green possess this power equally. A like assimilation may be laid down between the blue and the red. Finally, the power of illumination in the indigo rays, and above all in the violet, is very weak.

The memoirs of Herschel on Newton's colored rings, though containing a multitude of exact experiments, have not contributed much to advance the theory of those curious phenomena. I have learned, from good authority, that he himself held the same opinion. He said that it was the only occasion on which he had reason to regret having, according to his constant custom, published his labors immediately as fast as they were performed.

LIFE AND LABORS OF HENRY GUSTAVUS MAGNUS.

[FROM THE ARCHIVES DES SCIENCES PHYSIQUES ET NATURELLES, GENEVA.]

Translated for the Smithsonian Report.

The processes of scientific investigation have never been reduced to definite rules, and frequently methods are adopted of the most opposite character. Sometimes, impelled by the impulse of his genius to achieve immediate distinction the scientist discards beaten tracks and attempts to explore new regions by assays almost without a definite plan in a predetermined direction, and although the results of his trials in most cases are of a negative character, yet he occasionally lights upon facts rich in the indications of scientific principles. Sometimes, less a lover of novelty than of precision of knowledge, he prefers the critical examination of some region previously traversed by others in order to give it that minute investigation required in every part of the domain of modern science, and thus unostentatiously contributes essentially to the advance of science. These two methods are both fruitful and should not be entirely separated. The first, perhaps the more brilliant, requires an undaunted spirit, a creative genius. The second, more modest, but also more sure, requires extensive erudition, a critical mind, and great talent for experimentation.

The scientific career we are about to portray belonged essentially to the latter class. The part of Magnus was less to discover new phenomena than to reinvestigate and render more definite those already known. Such was the precision of his researches that he was frequently enabled to draw new truths from subjects apparently exhausted, and, in some cases, even to transform entirely, propositions generally admitted as truths. He valued little bold conceptions and even ingenious hypotheses when not supported by rigorous demonstration, while a fact apparently the most insignificant he would frequently regard as of the highest importance, provided it was fully established. Exact and conscientious in the extreme, he concentrated his efforts upon the minutiæ of his investigations, removing with the greatest care every cause of uncertainty. Of cautious and candid judgment he was not ready to find his scientific colleagues in error; and when a disagreement occurred between his results and those of another, his first impulse was to look for a mistake in his own experiments. Essentially modest, loving science for its own sake, and forgetful of self, he did not shrink from the most arduous labors, from investigations apparently the most unremunerative, and in this way, without ostentation, almost unconsciously he gained a solid and lasting reputation.

Henri Gustave Magnus was born in Berlin, May 2, 1802. He belonged to one of the most honorable families of that city. From his earliest infancy he manifested peculiar aptitude for the exact sciences and preferred study to the ordinary amusements of childhood. He passed through all the grades at the academy of Berlin, and received the degree of Doctor in 1827. His first researches were made in the laboratory of Mitscherlich; he next pursued his studies under Berzélius at Stockholm, where he passed the year 1828. Thence he went to Paris where, in the laboratory of Gay Lussac he prepared himself for the interesting experiments which he undertook a few years later. Returning to his native city he soon obtained a reputation as an instructor, which he ever after sustained with great distinction and unflagging zeal. He entered upon this career as private tutor; was nominated in 1834 extra professor, and in 1845 ordinary professor of physics and technology in the university of which he became one of the brightest ornaments. He exercised an important influence in developing a taste for the study of physics, as well as in imparting a knowledge of its principles in their most varied applications. For the illustration of the subjects of his lectures he formed the physical cabinet of the university, which was enriched after his death by the valuable collection of apparatus belonging to himself.

His first labors were devoted to physical chemistry. In 1825 he contributed to this branch of science, through the *Annales de Poggendorff*, an interesting memoir, on the property which iron, cobalt, and nickel, finely divided by a reduction of their oxides in a current of hydrogen, possess of taking fire spontaneously in the air at the ordinary temperature. He did not confine himself to the mere discovery of the fact, and to showing that it was an especial attribute of these three metals, but explained it on the principle of De Saussure, of the absorption of gas by porous substances, such as charcoal, and by showing that substances of this character, in consequence of their porosity, condense oxygen and enter into combination with it so energetically as to produce incandescence.

In 1828 he discovered the compound which has been called, in compliment to him, the green salt of Magnus. This is formed of the elements of chloride of platinum and of ammonia, and was the first of a series of combinations of the same substances. In an investigation in common with Ammermüller, he discovered the periodic acid, also the ethionic and istheonic acids, analyzed a large number of minerals, and observed the remarkable property which certain crystallized silicates possess, of losing by fusion a considerable portion of their weight.

We cannot stop to enumerate all the investigations of Magnus in this branch of science; we must hasten on to his numerous and beautiful researches in physics, which constitute his true claims to renown. These were especially devoted to molecular and calorific phenomena. His first work on physics, entitled "Researches on Capillarity," is rather a study of the flow of different gases, through minute cracks in glass vessels.

He throws new light on this subject, and shows the remarkable fact that here is an immense difference in the rapidity of the escape of hydrogen in comparison with other gases.

He published later some interesting observations upon evaporation in capillary tubes, which he found most rapid in the narrowest tubes, and upon the boiling of mixed liquids. In regard to the latter, he showed, as theory indicated, that this boiling takes place at the temperature when the sum of the tension of the mixed vapors is just sufficient to overcome the pressure of the atmosphere, consequently at a temperature a little lower than the boiling-point of the more volatile liquid. He observed that this condition is never realized when the more volatile liquid is placed below the other; the mixture in that case becomes overheated and commences to boil suddenly with a violent explosion.

It was also at this period of his life, in the commencement of his career as professor, that Magnus made his interesting experiments upon the gases contained in the blood. This subject has since been further developed, but the honor will always be his, of having materially enlarged the views entertained in regard to one of the most important functions of animal life. The theory of respiration most generally received before his day, was that of Lavoisier, according to which, the combustion of the blood takes place at the moment when it comes in contact with the air in the lungs. This theory was, in fact, the only one then possible, since the presence of gas in the blood, emitted by expiration, had not been shown. Magnus found in arterial as well as venous blood considerable quantities of oxygen, nitrogen, and carbonic acid. The sum of these three gases was, in his experiments, equal to the eighth part of the entire volume of gas. He found that in arterial blood the oxygen was from one-third to one-half; of the carbonic acid in the venous blood only one-fourth to one-fifth. From this he concluded that the oxygen does not combine immediately in the lungs with the carbon of the blood, but absorbed by the arterial blood it is carried into the capillary vessels, where it is employed in the combustion of the debris of the organisms. Carbonic acid is in this way produced, which is also absorbed and transported by the venous blood, and is breathed out at once on reaching the lungs. This theory is now generally adopted.

The researches of Magnus, which perhaps more than any other tested his talents for experimentation, are those upon the coefficient of the dilatation of gases. It had been generally admitted that this coefficient was the same for all gases, and that between 0° and 100° C. their volume increased for each degree 0.375 of their volume at 0. This law of Gay Lussac, confirmed by Dulong and Petit, had passed into the domain of undisputed facts, when, four years after the publication of the works of the French savant, a Swede, Rudberg, revived the investigation of this question, and found as value of the coefficient of the dilatation of air 0.3646. It was important that a quantity so continually applied in physical science should be positively determined,

and simultaneously two of the most skillful experimenters of the time took up this important subject. Magnus communicated the results of his experiments to the Academy of Berlin November 25, 1841, and a few days after, December 13, 1841, M. Regnault gave to the scientific Academy of Paris his researches upon the same subject. These memoirs are master-pieces. Magnus says, in the opening of his: "I decided to take up the study of this important question, knowing well that I should gain very little, if any, distinction by the work, however long or laborious it might be, since its object was only to confirm one of two figures already known." This, the dictate of his excessive modesty, is the only error of his memoir. Contrary to his opinion, the work was one of his strongest claims to renown.

Repeating first the experiments of Gay Lussac, which consist in observing the dilatation under constant pressure of a certain quantity of air contained in a glass globe, by means of a small globule of mercury, which rises and falls according to the dilatation in the slender neck of this globe, Magnus soon discovered that there were several causes for uncertainty, but found as mean result of his experiments the figure 0.369 instead of 0.375, probably on account of the greater dryness of the air. He then tested Rudberg's method. His apparatus consisted of a tubular reservoir of glass, communicating with a manometrical apparatus, and inclosed in a triple envelope of sheet iron, in the interior of which any constant temperature desired could be maintained. By increase of pressure the volume at 100° was reduced to what it had been at 0°. A very simple equation resulting from the law of Mariotte gave the coefficient of dilatation with the difference of pressure observed. The value of the coefficient thus obtained for the atmosphere was a very little greater than that found by Rudberg. Not content with this important numeral, Magnus experimented with different gases, and found for hydrogen a coefficient of dilatation less than that of the atmosphere, viz, 0.365659; for carbonic and sulphurous acids, on the contrary, coefficients of dilatation greater than that of the atmosphere; for the former, 0.369087; for the latter, 0.385618. The law of Gay Lussac was but an approximation to the truth. Magnus proved that gases did not dilate equally, as had been until then generally admitted.

M. Regnault had made four series of experiments. The first two, in which he changed at the same time both the volume and the pressure, gave him two coefficients for the atmosphere, both equally sure, 0.36623 and 0.36633. The third and fourth gave, with the volume constant and the pressure varied, 0.36679 and 0.36650 as coefficients of dilatation for the atmosphere. While operating on different gases, he had arrived at results very nearly identical with those of Magnus. The two experimenters concluded to replace the old coefficient 0.375 by the figure 0.366 for the atmosphere, and decided that the different gases dilated unequally.

The cause of the difference between the figure found by Gay Lussac

n one hand, and by Rudberg, Magnus, and M. Regnault, on the other, ras that upon the interior surface of the vessel in which the dilatation f the air was observed, there was a stratum of humidity which passed ıto the gaseous condition when the reservoir was heated to 100°, and hus increased the dilatation. It was evident that an effect of the same ind might be produced by the condensation of the gas itself, on the urface of the vessel. To prove the fact Magnus ascertained two ıeasures of the coefficient of dilatation of a single and the same gas, ulphurous acid, increasing greatly in one case the extent of glass sur- ace in proportion to the volume of gas coming in contact with it. This was ffected, by introducing a number of globules of glass into the reservoir ontaining the sulphurous acid. He obtained as coefficient of dilatation value greater than by the ordinary process without the globules of lass, and while confirming the fact that gases condense at low tem- eratures upon solid bodies, gave at the same time the measure of this ondensation.

After his researches upon the dilatation of the air at high temperatures ınd upon the tension of steam, finding himself again in competition vith M. Regnault, Magnus left the field to be explored by the illustrious French savant, with far greater resources than he could command, re- uming, however, at intervals, his favorite study of gases and vapors. n 1860 and 1861 he published a very important article upon the trans- nission of heat through gases in the double aspect of conductibility ınd radiation. Placing a thermometer in a glass vase heated moder- ıtely and filled successively with different gases or vapors, he found hat the thermometer was heated differently in different gases, and ndicated a lower temperature in any one of them than in a vacuum. He concluded from this that gases transmit very little if any heat by onductibility, and absorb a considerable portion of radiant heat. Only ne gas, hydrogen, he declared an exception to this rule, at least as regards he first point; the thermometer rises higher in this gas than in a acuum, notwithstanding, as he also observed, that it absorbs radiant ıeat in the same proportion as the atmosphere, azote, and oxygen. The thermometer rose higher when the gas was more dense, which seemed to indicate that gases conduct heat like the metals. This was ne proof more in confirmation of the theory, making a metal of hydro- gen, which has since been fully established by the beautiful experiments of Graham. This conductibility of hydrogen is well exhibited when it s surrounded by a non-conducting substance such as eider down or otton, so that the currents produced in it may not be disturbed.

As we have said, all gases, without exception, absorb radiant heat, and in greater proportion as the pressure is greater. Those which absorb the least are the atmosphere, nitrogen, and oxygen, and, almost to the same degree, hydrogen. Among colorless gases, ammonia first, then olefiant gas, arrests most readily the radiations of heat. The difference in the transmission of radiant heat through different gases varies with the

sources of heat employed. The most marked differences are obtained from a source of black heat at 100° C. As to the vapor of water contained in the air Magnus observed that it was appreciably absorbent only when in the condition of a transparent gas. This subject gave rise to a long controversy between Magnus and Mr. Tyndall.

The English savant had undertaken the study of this interesting subject and gave the results of his investigations in a discourse before the Royal Society only a few days before Magnus communicated his to the Academy of Berlin. The two savants agreed upon all points, except upon the transmission of radiant heat through damp air. Contrary to Magnus, Mr. Tyndal found that the vapor of water contained in the air absorbed radiant heat forty, fifty, and even sixty times more than the air itself; and yet this result was obtained, not with air absolutely saturated with moisture, but with ordinary open air or with that of his laboratory. The want of accord between the two experimenters in this particular remains, in spite of repeated efforts to discover the cause in their different modes of operating. Magnus accounted for the enormous absorption obtained by Mr. Tyndall by the condensation of the vapor upon the interior surface of the tube used, or upon the plates of rock-salt which closed the extremity of this tube. The English savant repeated his experiments with the greatest care, but always with the same result. The error, on whichever side it exists, remains undiscovered, and some idea may be formed of the difficulty of this question when two such skillful experimenters fail to solve it.

Magnus made other interesting experiments upon radiant heat, especially upon the variation in the emissive power of a body with the degree of polish of its surface, and he showed that the increase of this emissive power in an unpolished body is greater, not because the superficial stratum is less dense, but on account of its discontinuity. He also observed that the increase in the emissive power of platina was confined to the radiations of red or nearly red heat. He discovered, also, the property which sylvine or chloride of potassium possesses, in common with rock-salt, of being almost entirely diathermal and of transmitting equally heat proceeding from very different sources. It was interesting to find a new analogy between these two substances, which in many of their properties, as well as in their chemical composition, are completely identical. In respect to the remarkable diathermality of rock-salt, we shall see how entirely he modified the theory of Melloni, which had been generally adopted.

Shortly before his death Magnus published a memoir upon the emission, absorption, and reflection of heat by bodies at low temperatures. This article, given entire in the Archives, shows that different bodies emit, absorb, and reflect, at temperatures in the neighborhood of 100° C., very different calorific radiations; so that were our eyes capable of perceiving the radiations of black heat, the bodies exposed to them would appear to us of very different colors, as is the case when they are

submitted to luminous radiations. According to Magnus, rock-salt is not in the least athermochroic, that is to say, diathermal, under any kind of heat; it is, on the contrary, monothermal, emitting and absorbing only a very limited number of simple radiations; just as incandescent sodium emits only a few of the yellow radiations and excludes all other kinds of light. This result, certainly very curious and unexpected, should be investigated in regard to other bodies.

Magnus, as we have said, especially applied himself to the study of heat, but he enriched other branches of science with numerous observations, all of which bear the imprint of his acute and accurate understanding. We will say a few words only upon his researches in thermo-electricity. Taking up the experiments of M. Becquerel, who attempted to show that in an homogeneous circuit heated at one point, electricity is produced because the heat emitted on both sides of this point differs in quantity, Magnus demonstrated that the production of electricity in the connected wire should not be attributed to the unequal transmission of heat in the two portions of this wire, but to an alteration in its molecular condition. After having confirmed the fact announced by Matteucci, that there is no production of electricity when two masses of mercury are brought in contact at different temperatures, he showed that an abrupt change of diameter, either in a column of mercury, or in a perfectly homogeneous wire, does not necessarily give rise to a current of electricity, but on the other hand, electricity may always be excited by heating the point of contact of two heterogeneous portions of a single wire, for instance, when one part is hammer hardened, and the other annealed.

This sketch would be incomplete without some notice of the numerous articles published by Magnus in the memoirs and monthly issues of the Academy of Berlin, and also in the *Annales de Poggendorff*, many of which have reappeared in the "Archives," either translated or reviewed. We must, however, confine ourselves to a mere mention of his researches upon the movement of liquids; upon the deviation in the rotary motion of projectiles; upon the temperature of the earth at great depths; upon the tension of mixed vapors; upon the electrolysis; upon the action of the brace of magnets, and upon the diffraction of light in a vacuum. Such were some of the various subjects which engaged his attention and which he pursued with unceasing accuracy and care.

But it was not only by his numerous and laborious investigations that Magnus advanced the cause of science; he filled the office of Professor; was, in fact, the leader of the university. He loved youth, and knew how to make himself beloved while imparting a taste for that science to which he had consecrated his life; and we may, without exaggeration, say that he exercised an important influence upon the scientific generation which has succeeded him. He received many testimonials of the confidence he inspired in the young men of the university; among others, we may mention, that in the troubles of 1848, to him, a man preëminently

ral history with great zeal and enthusiasm; while he was equally earnest in giving instruction in the severer portions of the broad department for whose cultivation in the college he was made responsible. He fitted up a laboratory, and commenced making collections for the illustration of botany, mineralogy, and geology. This was accomplished mainly by personal labor and exchanges with those engaged in similar pursuits in our own and other countries. These labors gave the initial impulse to the cultivation of the natural sciences in Williams College, and laid the foundations of its now large and valuable illustrative collections.

In 1827, Dr. Dewey resigned the chair which he had so long held. The friends of education in Western Massachusetts had been impressed with the necessity of providing more systematic and vigorous instruction for young men preparing for college and immediate business pursuits. An opportunity for public service of this sort of more immediate usefulness, as it seemed to him, than was afforded by his college chair, was found in the establishment of a gymnasium at Pittsfield. He removed to Pittsfield, where he had previously been engaged as professor of chemistry in the Medical College, and became principal of this institution. He remained in Pittsfield nine years, at the same time occupying the chair of chemistry in the medical colleges in Pittsfield and in Woodstock, Vermont. At the end of this period he removed to Rochester, New York, and took charge of the collegiate institute in that city. This institution, in connection with Professor N. W. Benedict, he conducted with high success for fourteen years. In 1850, at the establishment of the University of Rochester, he was elected professor of chemistry and natural history in that institution, and continued to discharge the duties of that chair for a little more than ten years. He retired from active duty at the ripe age of seventy-six. It was during the period of his connection with the university that I first became acquainted with Dr. Dewey personally and in the work of instruction.

In attempting an estimate of the services and worth of our venerated friend, we are naturally led first to speak of him as a teacher. In his chosen profession he was an enthusiast. His whole life was absorbed in obtaining knowledge and imparting it to others. In the street, in the social circle, in the professor's chair, he was always the teacher. No person could come within the sphere of his influence without carrying away some new fact or thought, or being inoculated with new love for moral or natural truth. In accumulating knowledge he seemed always to have in mind the idea of imparting it to others. In his mind new truths seemed to fall spontaneously into the form best adapted for presentation to the learner. He always conceived of nature and man as belonging to a common system, related to each other in every part, and designed to illustrate a common moral purpose. This naturally led him to estimate new investigations and discoveries to be important mainly as they served to set forth the moral dignity of man, to promote his

appiness, and elevate his character. His intellectual life was a beautiful commentary on the remark of Gibbon, that "it is a greater glory o science to develop and perfect mankind, than it is to enlarge the boundaries of the known universe." He appeared to study nature, not so much for the reputation which knowledge or discovery would secure to him, as from a tender affection for her various forms and aspects considered as exhibiting a grand connection of benevolent uses, means, and ends, revealing the goodness and wisdom of the Almighty. Hence, he was utterly free from those petty jealousies which so often manifest themselves among scientific men. He rejoiced in scientific progress, to whomsoever it was due, and was always most generous in his estimate of the achievements of others. Every discovery which developed new elements in the Divine plan was to him a matter for personal rejoicing. Whittier's verses, describing St. Pierre's sympathizing relation to nature, are more strictly applicable to Dr. Dewey than to the brilliant Frenchman:

"She laid her great heart bare to him,
Its loves and sweet accords—he saw
The beauty of her perfect law.
* * * * * *
And thus he seemed to hear the song
That swept of old the stars along,
And to his eyes the earth once more
Its fresh and primal beauty bore."

To his mind there was no broad separation between the moral and the material order. But he was intensely averse to that false philosophy which seeks unity at the expense of reducing all thought and volition to dynamics, making no distinction between man and a crystal. To his mind, the whole scheme of material things was ever throbbing and quivering with divine life, benevolence, and power. This profound recognition of God in the modes in which He has revealed himself, rounded and completed his moral and intellectual life, and made him, by way of eminence, the Good Teacher.

His scientific attainments were supplemented by various and thorough knowledge in the department of critical scholarship. This gave a breadth and many-sidedness to his mind, which is so conspicuously wanting in many of the scientific men of our time. In the lecture-room, Dr. Dewey was exact and brief in his statements of principles; clear and full in his illustrations of difficulties; sympathetic with the dull in intellect, and patient with the wayward and inattentive. As a colleague, he was uniformly unselfish and courteous, bearing his share of all common burdens, ready to receive suggestions, never taking offense at trifles, exhibiting always that rare combination of natural qualities and acquired habits which distinguishes the Christian gentleman. He loved his work, continued in it during his whole active life, and neither sought nor wished for any other employment. It was his lot to have been connected with schools and colleges which have been recently founded

or were in the process of formation. For this reason his labors were the more self-denying.

He also represents two departments of the teacher's profession. He went from a college chair, in which he had been eminently successful, into an academy, and from an academy back again to a college chair, simply at the call of duty, apparently without a thought that dignity or position was in the slightest degree affected by either transfer. His only desire was to ascertain the position in which he could be most useful to his fellow-men. In view of these facts in our friend's career, I cannot forbear to note the lesson which they convey to our profession. As teachers, we should always bear in mind that we belong to a brotherhood laboring in a common work for a common end; that rank and dignity among us do not depend upon the accidents of position, but upon high attainments and faithful services, no matter where those attainments are made or those services rendered. In this respect the legal profession gives us a worthy example. From the Chief Justice of the United States to the village attorney, all lawyers, as members of the profession, are brethren, and equal. Let us frown upon any attempt to separate our profession into sects and orders, on the false assumption that there are, or can be, rival dignities or clashing interests among those engaged in the high and benevolent work of training the minds and characters of the young.

As a man of science, Dr. Dewey belongs to a class whose abilities and public services are liable, in our time, to be overlooked or underrated. I refer to those men who were pioneers in the work of cultivating and popularizing natural science in our country. When Amos Eaton, Parker Cleaveland, Robert Hare, Benjamin Silliman, Edward Hitchcock, and Chester Dewey began their labors, the natural sciences, as they are now understood, had in this country hardly an existence. Since that time the discoveries and investigations upon which they rest have, in great part, been made or matured.

Dr. Dewey left college in 1806. Just about this period that remarkable impulse was given to scientific inquiry, resulting in an almost simultaneous development of chemistry, zoölogy, crystalography, botany, and geology, which rendered the first half of the nineteenth century so supremely illustrious. What are now elementary truths, finding a place in every text-book, were then either undiscovered or new and strange, waiting the time of their acceptance or verification. The very year of Dr. Dewey's graduation, Davy made his discovery of the metallic bases of the alkalies, and promulgated the electro-chemical theory by extending and applying the discoveries of Galvani and Volta. A few years previous, Lavoisier and his associates had published their new system of chemical nomenclature. In 1807, Dalton's law of chemical equivalents and definite proportions was first given to the world. Hüny, Weiss, and Mohs published their new views on crystalography from 1800 to 1809, while Berzelius and others were at the same time developing the chem-

cal system of mineralogical classification. The natural system of botany, founded by the younger Jussieu, was, during this period, slowly making its way to public favor. Cuvier's "Fossil Bones," which first raised geology to the rank of a science, was not published till 1812. The "Animal Kingdom," which rendered a similar service to systematic zoölogy, appeared in 1817. William Smith, who, in England, was learning to describe strata in different parts of the island, and to identify them by their fossil remains, gave his results to the public about the same period, his most important work having been published in 1815. Many other facts in the history of science, which will occur to those who now hear me, illustrate the fact that our scientific pioneers labored under the disadvantage of having begun their career with the infancy of the sciences which they cultivated. They grew intellectually with the growth of natural knowledge, and their active lives stretched over the whole period during which these sciences were born and reached maturity.

The scientific attainments of these men were not made like those of young naturalists in our time, by the study of a body of coherent and established truths, or by the accumulation of new facts which take their places naturally under laws already verified, or fall into classifications already fixed and named. Their attainments were made amidst sudden and almost violent revolutions in method and changes in fundamental ideas, which were startling to the timid and bewildering to the weak. It required no ordinary courage and manliness, no ordinary faith in the universality and coherence of the Almighty's plan in the universe, to accept and promulgate ideas which seemed subversive of all established opinions—utterly superseding and setting at naught the "wisdom of the ancients."

The facilities for the acquisition of new facts, and the testing and verification of the new hypotheses, were inadequate in the extreme. Laboratories and apparatus were to be created or invented. Cabinets of minerals were meager, and collections of fossils were almost unknown. A single illustration in point we give from an article in Silliman's Journal for 1865. It will be borne in mind that Professor Silliman, senior, was appointed professor of chemistry and natural history in Yale College in 1805. The college was then over a century old, and under the presidency of Dr. Dwight. We are told that "not only the chemical laboratory, but also the cabinet of minerals, owed its existence to his [Professor Silliman's] energy. * * * About the time when Mr. Silliman was appointed a professor, the entire mineralogical and geological collection of Yale College was transported to Philadelphia in one small box, that the specimens might be named by Dr. Adam Seybert, then fresh from Werner's school at Freiberg, the only man in this country who could be regarded as a mineralogist sufficiently trained for that work." This illustrates the facilities for the study and illustration of natural science at Yale College, and we can readily infer the discouraging circumstances under which Dr. Dewey began his work and collec-

tions in Williamstown. Such facts ought to impress the present generation with an idea of the zeal, energy, and ability of men who, in such a state of things, could devote themselves to scientific pursuits.

It should be recollected, also, that these pioneers in science were not left free to devote any considerable portion of strength and time to investigation and the accumulation of specimens. They were generally overburdened with the work of giving instructions in subjects now distributed into three or four departments. Transactions of learned societies were procured with difficulty. Scientific journals were few, and in our country unknown. Communication with Europe was slow and expensive. The languages of modern Europe had not then been introduced into the courses of public education, and few, comparatively, could command the time or means to acquire them, or to travel abroad for the purpose of observation and study. These sciences, themselves, being in a formative state, were not differentiated, nor their limits marked out. These men, of necessity, studied nature in the mass, meeting often the unclassified subject-matter of several sciences in a single investigation. They constantly encountered the difficulties resulting from faulty and incoherent terminology. Their memories were burdened in keeping abreast with the changes of names which rapid scientific progress made necessary. Classes as well as names were in a state of constant flux, for we all know that an adequate terminology always follows and never precedes the knowledge of systems and laws. Their experience confirmed the maxim of the French savan, that "science est un langue bien fait." The tax upon time and memory, requisite to keep abreast of the rapid movement of thought and discovery, was enormous. Their mental experience became a register of the mass of the false hypotheses, blunders, changes, revolutions, discoveries, and generalizations which make up the brilliant and varied history of modern science. They were obliged to acquire an equal facility in learning and unlearning. The task of laying aside what had been painfully acquired, and which some brilliant discovery had suddenly proved to be useless or erroneous, was severer than the acquisition of what was new.

In addition to all this, they were obliged to make a place in an already occupied curriculum of college study, for their favorite studies, and to vindicate to the public mind their dignity and value. Like the early settlers of our unbroken forests, they were obliged to remove obstacles, and furnish a career for those who were to come after them. It is not strange, then, that the attainments of such men were affected and modified by the conditions of their scientific life—that their knowledge was less specific in its form, less methodical in its arrangement, than that of their successors at the present day. It is not strange that in the presentation of subjects they did not take note always of those metes and bounds which the accumulated thought of half a century has set up—that their mental furniture was encyclopædic and compendious, rather than minute, classified, and exhaustive. The immense range of the natural sciences, now that the work of evolution has been so far com-

pleted, makes specialization in study a necessity. But it may be carried too far, both in the neglect of general culture in the scientific investigator himself, and in the failure to attend to branches of science cognate to that specially chosen for cultivation. We believe that in the end nothing is gained to science by the neglect of those elements of scholarship which belong, by common consent, to liberal education, in order to concentrate the activity of an entire life, from boyhood to age, upon a particular branch of science. Against such a course the whole example and precept of our scientific fathers was directed. There is, in our own time, a tendency to confound the spheres of professional and general education, and to sacrifice liberal culture to special attainment. This seems to me an evil which should be resisted. A distinguished chemist remarked, not long since, that it was a cause for constant regret that his students in analytical chemistry came to him so often without liberal culture and discipline in letters, and general scientific knowledge and method.

We may also question whether the disposition to specialize, among investigators and professional scientific men, may not be carried to excess. May not what is gained to science in the more rapid accumulation of facts, through exclusive devotion to some narrow range of inquiry, be more than lost through the resulting deficiency in breadth of view? A man who carries specialization to extremes, will become intellectually purblind, and fail utterly in an adequate comprehension of the material and moral cosmos, considered each as parts of one vast whole, finding its unity in the mind of God. Said a great naturalist, the other day: "I am more and more convinced of the solidarity of the sciences. I am more and more inclined to distrust the observations of a man who is familiar with but one narrow branch of inquiry." Does not knowledge, by such specialization, grow faster than wisdom, breadth, and power? The effect of extreme division of labor, in manufactures and trade, in diminishing general capacity, intellectual and physical, has been often noted by economists. The guardians of public education, as well as of scientific progress, may well be warned of an analogous danger. "The more deeply the sciences are investigated," says a great historian, "the more clearly is it seen that they are all connected. They resemble a vast forest, every tree of which appears, at first sight, to be isolated and separate, but, on digging beneath the surface, their roots are all found interlaced with each other." Whatever advantage comes from a broad survey of the field of scientific inquiry, accrued to our scientific pioneers from the very necessities of their position. The broad, catholic sympathy of these men with all branches of science, stands in sharp contrast to that narrow scientific sectarianism which has too often disgraced scientific associations on both sides of the Atlantic.

At a time when scientific men of certain sympathies and opinions speak of religious men as obstacles to scientific progress, it is well to bear in mind the fact that the fathers of American science were, almost to a man, earnest believers in the divine authority of Christianity. The

institutions of learning in which, and through which, they labored, were all of them founded, endowed, and sustained through the efforts and sacrifices of religious men, and especially of the clergy. The pursuits of physical science are superficially thought unfavorable to moral and religious growth. But so long as we can recall the elevated spiritual life of such men as Silliman, Hitchcock, and Dewey, we need no other refutation of such an idea.

In connection with his labors in giving instruction in colleges, medical schools, and academies, Dr. Dewey was not unmindful of his obligations to make some additions to the sum of scientific knowledge. He was for forty years a constant contributor to Silliman's Journal. He always studied with pen in hand, and was a constant writer on scientific subjects for the newspaper press. He became early in life an enthusiastic student of botany, and contributed very largely to the scientific knowledge of the *carices*. Dr. Asa Gray, our great botanist, classes Dr. Dewey with Schweinitz and Torrey, and speaks of his writings on caricography as an "elaborate monograph, patiently prosecuted through more than forty years." He further says that, in connection with the two botanists above mentioned, "he laid the foundation and insured the popularity of the study of the sedges in this country." Unfortunately, Dr. Dewey did not write any systematic treatise on this subject, but his numerous short articles represent the progress of his own observations and studies, and give a history of the progress of that department of botanical science. Dr. Dewey wrote a History of the Herbaceous Plants of Massachusetts, which was published by the State. He contributed, also, the article "Carices," to Wood's Botany. Up to the last year of his life, our friend's mind showed the vigor and enthusiasm of his early years, and he was constantly writing on scientific topics. His last publications of any length were two review articles, one entitled "The true place of man in zoölogy;" the other, "An examination of some reasonings against the unity of mankind." These articles were read first before a literary association in Rochester, of which the Doctor was a member. They displayed a full and intelligent familiarity with all the most recent discoveries and speculations bearing upon these difficult and complicated questions. His discussions were conducted with an ability, clearness, and learning which, at his age, were surprising. His industry in study was unremitting, and up to the very last year of his life his mind was open to examine, with utter freedom from prejudice, any new discovery or speculation which was worthy of attention. His last labors were the orderly arrangement of his large collection of sedges, which had been for so many years accumulating on his hands, and copying out his meteorological journal. Just before his death, while engaged upon his journal, his hand became unable to hold his pen, and, calling for the aid of his daughter, he placidly remarked that this would be his last report to the Smithsonian Institution. He died calmly, of old age, on the 15th of December, 1867, in his eighty-third year. He

and the control of his faculties to the last, sustained by an unfaltering trust in the blessed life hereafter.

A few remarks further, and we close. All who knew Dr. Dewey were impressed with the freshness and vigor of his mind even up to the latest period of his life. I have often asked myself this question: How did Dr. Dewey retain so fully his mental activity, and grow old so gracefully? This result seemed to me due, in the first place, to his constant effort to keep abreast with the movement of modern discovery and thought. He never was satisfied with falling back on past experience or old attainments. He believed that morally, intellectually, and physically, man is making progress. He held it to be his duty as long as he lived to contribute to that progress, and to be himself a vital part of the movement. He was always at work; always acquiring new ideas. Morally and scientifically, his mind and sympathies were with the future, and not with the past alone. Hence, his brain never became inactive; the currents of his intellectual life never grew stagnant and dull. His topics of conversation were always of the present and the actual, or of some new application, modification, or adjustment of the old and the tried.

Again, he kept up, in a wonderful degree, communion and sympathy with the young. With them he established friendships and intimacies. In these intimacies, his stores of knowledge and ripened wisdom were poured out freely, while the young gave back to him the cheerfulness, confidence, and hope natural to their time of life. He was always a guide and helper to young and struggling men of talent. The number of such who, by his impulse, advice, and encouragement, were led to honor and success, was very great. No young scientific laborer ever failed to find a wise and sympathetic friend in Dr. Dewey. Nothing gave him greater joy than the rising distinction of some protegé whom he had started on the road to fame. His beautiful old age most emphatically belied Horace's oft-quoted description of the aged man:

> "Difficilis querulus laudator temporis acti
> Se puero, castigator censorque minorum."

No one was more warmly welcomed in society, by old and young, than he.

He kept his youth, too, through the simplicity, purity, and elevation of his moral and religious life. His trust in the moral order was as habitual and as firm as it was in the law of universal gravitation. This gave steadiness to his moral action, and so abated the ordinary friction and annoyances of life, that he seemed, to a casual observer, almost insensible to their action. For fifteen years I was favored with the friendship of Dr. Dewey. A large part of that time I met him daily as a colleague. I was associated with him during the period (always trying to an old man) when, at the age of seventy-six, he ceased to discharge the active duties of his chair; and I can say, with perfect sincerity, that to me and his colleagues he seemed incapable of injustice

or bigotry, of meanness or malice, of envy or suspicion. We all honored him as a sage; we loved him as a father. I have never yet met a man who so completely, as he, illustrated the moral elevation and spiritual beauty of the Great Teacher's Sermon on the Mount. What he was to his family and friends, he was to the multitude who knew him but partially and indirectly. To the whole population of Rochester his presence in the streets was a benediction

THOUGHTS ON THE NATURE AND ORIGIN OF FORCE.

By William B. Taylor, of Washington.

The great generalization of our age—the continuity or indestructibility of force—confirmed as it is by a constantly accumulating series of inductions, contradicted as it is by no adverse fact, comes gradually to impress itself upon our convictions almost with the positiveness of an axiom. And yet a slight consideration will show us that it is really but a corollary from the particular constitution of matter presented constantly to our observation. Had we any example of an incompressible substance wholly devoid of elasticity—that is, possessing no molecular or atomic repulsion, (to adopt the conception entertained by Newton and his followers,) but endowed with only cohesive and gravitative attractions—then for such matter the theory of the conservation of force would not be true. Were two equal balls of such a material to meet in space with equal and opposite velocities, at the moment of impact there would be, with the arrest of motion, the actual destruction of the entire living force they jointly possessed. Not only would there be no rebound, but there would be no internal molecular work effected, and no heat generated to represent a surviving or transformed energy.

The doctrine of the correlation and conservation of forces depends therefore upon the coexistence in all matter of two opposing tendencies, namely, those of *attraction* and *repulsion;* and from the ceaseless play and struggle of these opposing tendencies are derived ultimately all the varied phenomena of the visible universe.

The most ordinary and obvious manifestations of force are those exhibiting motion; as in the whirlwind and the cataract, the volcano and the earthquake, the steamship and the locomotive train. There has accordingly been a very general tendency to confound force and motion; and this fallacious confusion has not unfrequently vitiated the reasonings of even intelligent writers.

To distinguish, however, motion from force on the one hand, it may be remarked that they never have a common measure; and to distinguish force from motion on the other hand, it is only necessary to consider the fact that we are surrounded by a vast array of *statical* forces, continually resisting the most energetic solicitations to motion.

First, as to the absence of a common *measure:* It is found that the rate of motion follows only the law of the square root of the force originating it. A double consumption of fuel will not double the speed of a locomotive-engine. On the contrary, (as is well known to the engineer,) four times the quantity of fuel is necessary to attain this duplication of

effect. So if a pound of gunpowder will impel a cannon-ball with a given velocity, it will require four pounds of powder to double that velocity. The conservation of force, however, is maintained in the fact that the penetrating power of the cannon-ball is directly proportional to the energy expended in its propulsion; or, in other words, to the square of its velocity. Or, to express the distinction in the established formula, while $m \times v$ represents the quantity of *motion* in a moving body, $m \times v^2$ represents its quantity of *force*.

Secondly, in regard to *static* force: Every one who has ever attempted to hold aloft a heavy weight as motionless as possible will have had a realizing sense of the expenditure of energy required, not to *produce*, but to *prevent* motion. The Suspension Bridge at Niagara, safely upholding its thousands of tons of loaded cars and human freight over the frightful chasm beneath, may be cited as one among an infinite number of examples of statical force, or of *power in repose*.

The avalanche, hurtling down the mountain side with destructive violence, overwhelming a village and its inhabitants, is but expending a force stored up a year or years before, by the sun, when it lifted the mass, molecule by molecule, to its position of latent or potential energy.

Every pound of coal possesses a static or potential force of ten million "foot-pounds." That is to say, the power expended by the sun in raising the pound of coal from its low estate of chemical combination, or a satisfied affinity, to the higher plane of isolation and capacity for chemical reunion, was a power capable of lifting one thousand pounds of water to the height of ten thousand feet. And, conversely, the pound of coal thus chemically raised has itself received the power of mechanically lifting that immense weight to that enormous height.

It must be borne in mind, however, that when the sun actually does lift a thousand pounds of water to the height mentioned, it does not raise it bodily as water; it performs the vast additional labor of tearing asunder the entire mass, molecule by molecule, in opposition to the statical force of an intense cohesive attraction: a work of more than ten thousand "foot-pounds;" an expenditure of energy greater than that required to grind the same weight of ice (one thousand pounds) to the most impalpable powder. Deducting, therefore, this expenditure (a little over ten thousand "foot-pounds") we should find that the pound of coal represents, in a static form, an invested power equivalent to the lifting of one thousand pounds of water a little more than one foot, in addition to the task of evaporating the whole amount.*

Matter in motion being thus merely a vehicle of force, it follows that wherever dynamic or kinetic energy is transformed into potential energy, (as in pumping up water into an elevated reservoir,) there motion is to this extent destroyed; wherever potential or static energy is transformed into dynamic, (as in the discharge of a loaded pistol,) there motion is

* This of course does not include any actual *heating* of the water. One pound of coal will raise thirteen thousand pounds of water 1°; which is equivalent to only seventy-two pounds of ice-cold water (32°) raised to the boiling point, (212°.)

created. A very striking example of the continual transformation back and forth of these two conditions of force is presented in planetary movements, especially in those of considerable eccentricity. Taking the case of a cometary orbit, for example, whose greatest elongation should extend beyond the distance of Neptune, while its perihelion should lie far within the orbit of Mercury, we should find that the body, rushing or falling toward the sun with accelerated rapidity, would finally acquire a velocity of a hundred or two hundred miles per second; when its accumulated momentum would suffice to hurl it off as a projectile to its remote aphelion, where its velocity would be reduced to two or three miles per second, and the body be again in a condition to repeat its mighty oscillation. And this majestic pendulum, occupying some three-quarters of a century in its excursion, while exhibiting successively so enormous an absorption and alternate generation of motion, would at the same time illustrate the constancy and indestructibility of its force, in its transformation from the latent to the actual, and *vice versa;* the *vis-viva* of its lowest speed, plus its co-existing potential of gravitation at highest elevation, being exactly equal to those of its highest speed and lowest fall.

And yet, obvious as these truths appear, an acute and comprehensive thinker in an admirable exposition of the doctrine of evolution, has devoted a chapter to the unfortunate fallacy of the "Continuity [or indestructibility] of Motion." If it be once admitted that motion can be transmuted into any other form of force, then of necessity it cannot exist also as motion. The loose brick balanced on the chimney top, ready at a sudden gust of wind to topple and to strike a passer-by to earth, has a potential force, imparted to it perhaps fifty years ago by the hod-carrier and the brick-layer who raised it and placed it in its seat of power. During all these fifty years it has lain there quiet. True, it has partaken of the earth's rotations and revolutions; true, it has responded faithfully to all the varying, never-ceasing vibrations of summer-heats and winter-colds; and in all this passive acquiescence it has but illustrated its inertia. But this is manifestly altogether foreign to what we are considering. Whence, then, the motion that, commencing with the fall from the chimney, hurled back the brick to the earth from which it had so long before been lifted? The blast that tilted it was but the trigger which set free its latent power. Shall we say that the original motion imparted to it was also *latent* during all these years? Such an expression as "latent motion" is but a senseless contradiction of terms. The cap-stone of the great pyramid, elevated to its dizzy height with much effort and labor, might possibly remain there unmoved forever.

The simple truth is, that so far from our having any warrant for the assumption that the sum of all the motions in the universe is a constant, the repeated creation and destruction of motion is on the contrary necessarily involved in the indestructible transmutability of force.

These considerations, of course, apply equally to all the various kinds of *molecular* movement, such as those of light, of heat, and of electrical currents. It is familiar to all that we can create heat, as when we kindle a fire in the stove, or pass an electrical current through an imperfect conductor, or simply rub two sticks together. It is equally familiar that we can destroy heat, as when we employ steam-power for welding, forging, rolling, or swaging iron, and measure the effective work performed in these operations by the amount of heat abstracted from the steam, and forever destroyed as heat. In brief, whenever heat or other movement has produced a changed effect in matter, either internally or externally, there and to that precise extent has the motion (whether molar or molecular) entirely disappeared.

It is true that we still hear the convenient term "*latent* heat" frequently employed; but while holding in all honor the researches of Black, who first unfolded to us the curious phenomena grouped under this title, we now know by the clear light of the dynamic theory that there is no such thing as *latent* heat; that if heat be not sensible, or actual, it is not heat at all. We now know that the 142° necessary to liquefy melting ice without any increase of temperature, and the 965° absorbed in effecting the evaporation of boiling water, have had to overcome great molecular resistances; and that the internal work thus performed in raising the water to a higher potential is exactly measured by the amounts of heat respectively thus expended and consumed. When, true to the eternal law of conservation, precisely similar amounts of heat are obtained by a reversal of the several processes, these temperatures are as much a new creation or transformation as when we ignite the carbureted hydrogen at our gas-burners, or the anthracite in our grates.

No one would think of saying (excepting metaphorically) that we were releasing the light and heat stored up—in the one case at the retorts of the gas-factory, and in the other in the carboniferous laboratory of the solar actinism—a million years ago. Heat latent in coal-fields which may perchance have lain immediately beneath colossal *glaciers* for thousands of years! As well might we speak of the blaze emitted by the petroleum lamp as original sun-light which has been latent all these millenniums.

Undoubtedly the more accurate designation of the fact is, that when motion has resulted in static condition, the motion is absolutely destroyed; when from that condition a succeeding motion is evolved, a new motion has been as absolutely created; that when one kind of motion has been transformed into another kind of motion, the *equivalence* of the two by no means involves the *identity* of the two.

Among the multitudinous metamorphoses of force presented to our observation, we find not unfrequent examples of motion rising higher than its source. These cases may, however, all be likened to the familiar illustration of a large weight on the short end of a lever lifting a lighter weight on the other end as many times as high; or to the par-

allel instance of a considerable body of water by its momentum raising a smaller quantity to a higher level in the hydraulic ram. Similar instances of water-power occur in nature, as at the mouths of rivers, and at estuaries, where the contracting channel transforms a large mass movement into the potential of elevation. A magnificent example of this is furnished in the Bay of Fundy, where a huge tide of seventy feet is derived from an ocean-wave probably not exceeding two feet in height.

As in visible or *mass* motion, the matter may be either falling to a lower state of power, (as in the descending weight of a clock or the falling water of Niagara,) or rising under a superior external propulsion to a higher state of power, (as in a clock being wound up or ocean-water being evaporated by the sun,) so in *molecular* movements, the matter may be either running down, (as in combustion, or in the decomposition of quaternary or ternary compounds into more stable binary compounds,) or the matter may be raised to higher power, (as in the vegetable deoxidation of carbon by the sun's rays, or in the building up of animal substance to more complex and unstable conditions, by the power derived from other matter running down.)

Now, in all these wondrously varied and complex transmutations of force, while it is certain that the sum of all the static and kinetic forms of energy in the universe is a constant, which the human race with all its endless appliances of machinery can no more increase or diminish than it can add to or subtract from the quantity of matter, yet it is equally true that the store of the former, or the potential in Nature, is being in the aggregate diminished by transfer to the condition of the latter or the dynamic; and that in this transfer the general tendency is to a form of temperature of greater diffusion, and less capability of further transformation. So that solar and planetary systems are constantly running down to a lower plane of power—the former by the radiation of high heat, the latter by the radiation of low heat—into empty celestial spaces.* There is on the whole, therefore, as Professor Sir William Thomson has well designated it, a "Dissipation of Energy."

In a paper "On a Universal Tendency in Nature to the Dissipation of Mechanical Energy," presented to the Royal Society of Edinburgh, April 19, 1852, Professor Thomson arrives at the conclusions, that "there is at present in the material world a universal tendency to the dissipation of mechanical energy;" and that "within a finite period of time past the earth must have been, and within a finite period of time to come the earth must again be, unfit for the habitation of man as at present

* The whole amount of solar energy incessantly expended on our earth may be estimated at the amount of 208 billion 498,027 million "horse-power"—a horse-power being equal to 550 foot-pounds per second. But as was shown by the illustrious Dr. J. R. Mayer in his *Beiträge zur Dynamik des Himmels*, (Heilbronn, 1848,) the amount of solar heat intercepted by the earth is to the whole amount radiated into space "as 1 is to 2,300 millions." (*On Celestial Dynamics.* Translated by Dr. H. Debus, *L. E. D Phil. Mag.*, April, 1863, Vol. XXV, p. 245.)

constituted; unless operations have been or are to be performed which are impossible under the laws to which the known operations going on at present in the material world are subject."* And in a communication to the British Association in September, 1861, on "Physical Considerations regarding the Possible Age of the Sun's Heat," Professor Thomson repeats, that "although mechanical energy is indestructible, there is a universal tendency to its dissipation, which produces gradual augmentation and diffusion of heat, cessation of motion, and exhaustion of potential energy, through the material universe."†

In glancing thus cursorily at the nature of force, and its more striking manifestations, it is hardly necessary to allude to the now recognized correlation of the organic and so-called "vital" forms of power with the purely physical and kinetic. It has been reserved to our own day to see established in all its fullness the grand dynamic equation—"*Causa æquat effectum.*" It has been shown by the most varied series of experiments and observations that physiological, like mechanical processes, are possible only on the sufficient consumption of fuel; that growth, and development, and muscular movement are derived from the oxidation of carbon and of tissue, whose products may be accurately measured; and are all but phases of the ever-changing, never-dying energy of Nature.

Perhaps each one who should consult his "consciousness" alone (that witness so important to the metaphysician) would feel a conviction that when he strikes a blow he is exerting an original and self-derived power. And yet it is certain that the will of an Alexander, a Bonaparte, or a Bismarck, would be as impotent to move a grain of sand without an adequate supply of pre-existing external force placed at its disposal, as to launch the Great Eastern from its ways without a similar supply.‡

* *L. E. D. Phil. Mag.*, October, 1852, Vol. IV, p. 304.

† Report of Thirty-first Meeting, &c., *Notices and Abstracts*, page 27. (Republished in the *L. E. D. Phil. Mag.*, February, 1862, Vol. XXIII, p. 158.)

‡ It is proper to notice here a caution which has been suggested, that the will, though admitted to be merely a starter or director of the animal store of material force, must still exert and therefore originate the power, however small, necessary for such initiation. Sir John Herschel, in an essay "On the Origin of Force," remarks: "The actual *force* necessary to be *originated* to give rise to the utmost imaginable exertion of animal power in any case may be no greater than is required to remove a single material molecule from its place through a space inconceivably minute; no more in comparison with the dynamical force *disengaged* directly or indirectly by the act than the pull of a hair-trigger in comparison with the force of the mine which it explodes. But without the power to make *some* material disposition, to originate *some* movement, or to change, at least temporarily, the amount of dynamical force appropriate to some one or more material molecules, the mechanical results of human or animal volition are inconceivable. It matters not that we are ignorant of the mode in which this is performed. It suffices to bring the origination of dynamical power, to however small an extent, within the domain of acknowledged personality." (The *Fortnightly Review* for July 1, 1865; Vol. I, p. 439.)

This directing capacity of the animal will, like that directing impulse which presides over the entire domain of organic evolution, eludes all analysis, and hence has no recognized dynamic equivalent. Without attempting to discuss here this very abstruse

A demonstration of this is seen in the case of motor-paralysis, (which may be likened to the state of a steam-engine with the cylinder-valves locked in position, or detached from the eccentric,) or in the case of that extreme prostration which follows a low fever or prolonged illness, which may be likened to the condition of an engine whose head of steam is insufficient to overcome the inertia of the piston.)

But not only the animal processes of nutrition, growth, and movement are maintained *ab extra*, but those more subtle and mysterious processes of thought, emotion, reason, are alike the product of material metamorphosis; and their activities may be determined by the urea and the phosphates, and even phosphoric acid, eliminated by the kidneys. A large-brained man sitting idly in his easy-chair, with eyes closed to external impressions, and indulging in pleasant revery, might seem to be the very impersonation of self-contained and self-originating action. But apart from the chemical tests alluded to, which would demonstrate the fact of matter potential, undergoing a descent, we may employ the more direct and delicate indicator, a thermo-galvanometer, in connection with the back part of the dreamer's head, and we shall observe the needle to quiver and to fluctuate with the current of the varying thought. Let a knock be heard at the door, and though no movement of the face, no tremor of the closed eyelid betrays to the observer a consciousness of the sound, yet this tell-tale needle (sensitive to the two-thousandth part of a degree Fahrenheit) will attest by a deflection of many degrees of arc the aroused attention involuntarily excited through the action of the auditory nerves.* Here, then, we

point, it may be remarked that our faith in the doctrine of the constancy of force need not be shaken by this sole outstanding difficulty, or apparent limitation of its universality; and that however unable we may now be to explain or suggest the *how*—this last residuum, "will-power," (admittedly very small relatively to the product of voluntary force,) as well as that organic-power which determines that from the equal stores of force laid up in the two eggs of a duck and of an alligator, or of a dove and of a serpent, the one shall be directed to evolve a bird and the other a reptile—may yet be hereafter referred to the magazines each serves to unlock, or else to a principle entirely outside of mechanical force.

*In an interesting account of "Experiments on the Relation of Heat to Mental Work," by Professor J. S. Lombard, M. D., of Harvard University, employing a galvanometer capable of indicating about the five-hundredth part of one degree Fahrenheit it is stated that the ordinary variations observed resulting from mental action did not amount to more than about the fiftieth of a degree, though quite marked. "Pursuing these experiments further, it was found that anything that aroused the attention was capable of causing a greater or less rise of temperature on the part of the head, over and above that of the body." With the exercise of the higher reasoning powers, "the highest rise noticed did not exceed the twentieth of a degree," (about one-eleventh of a degree Fahrenheit,) while "the temperature of the extremities fell." "The most striking effects of all were produced by the reading aloud or the recitation of poetry." "Reading or reciting to one's self gave similar results, and often even in a more marked degree." "In the last-mentioned series of observations, it was not unfrequently found that the temperature of the forehead *fell*, while that of the back of the head rose; but for what reason, I have not yet been able to determine." (*The New York Medical Journal* for June, 1867, Vol. V. pp. 198–205.)

would seem to have almost the germ of a phrenometer, as if in defiance of the protestation that "thought cannot be measured." It is but just, however, to admit that this (although in some sense a phrenoscope) is not properly a phreno *meter*, since the effect determined is really only a resultant of the mental activity, and not its measure. The thermal indication represents (if the expression may be allowed) merely the friction of the mechanism.

On comparing the modes of derivation of force in machines (especially in those known as heat-engines) and in animals, we find that the transfer is made in substantially the same way. Matter previously raised to a chemical state of power is oxidized, and, in running down by this process of combustion, (whether slow or rapid,) evolves a molecular activity, which is absorbed and utilized in various ways, according to the exact seat of the transfer. Where deoxidized metals are the source of the power, (as in the galvanic battery,) the process is very similar. In this case, and in mechanisms operated by springs or weights, the potential force is first imparted by human labor.

The source of power, therefore, in machinery, as in the animal economy, is derived almost entirely from the vegetable kingdom; in which, matter which has been largely exhausted of its store of force by the engine and the animal, and discarded as carbonic acid, water, and other burned products, is raised again by the action of the solar energy to its static plane of chemical potentiality. And it is an interesting and significant fact that the two great vegetable staples consumed by the dead and by the living mechanisms respectively are identical in composition; that the *cellulose*, which is the principal food of the engine, is chemically isomeric with the *starch* which is the principal fuel of the animal. And the cellulose of the one, equally with the starch of the other, may, as is well known, be converted into sugar. It is hardly necessary to explain in this connection that the mineral coal so largely utilized, is itself but a metamorphosed cellulose; whose hydrogen and oxygen, (the elements of water,) expelled by geologic heat, have left remaining the carbon almost in a state of isolated purity.

Nor does it detract from the value of this parallelism between the diet of the inorganic and organic worker, that the latter (the animal) has not been so organized as to be capable of availing itself *directly* of the stored force in woody fiber; equal though it be to that which it has been adapted to assimilate.

It is important that we should endeavor to form some conception (however inadequate) of the physical mode of action and of derivation of the various forms of force presented to us. When a bell is struck with a hammer, the metal beneath is carried by the momentum or the *vis-viva* of the blow, beyond its condition of equilibrum due to the rigidity or molecular adhesion of the material; and then instantly recoiling, thus sets up a vibration counting tens, hundreds, or thousands to the second, according to the inertia, or the mass set in motion; which

oscillatory motion is finally destroyed only by external and internal resistances. In a manner somewhat analogous to this, the molecules of all matter balanced between opposing attractive and repulsive tendencies are forever ringing (so to speak) in response to continual disturbances, though with a rapidity inconceivably greater than any known as sound. Thus, when a gas-jet has its surface of contact with the atmosphere smitten with a spark or blaze, the molecules of oxygen and those of hydrogen and carbon rushing or falling together under the impulse of an attraction known as chemical affinity, with a violence so great as to impinge severely on their several spheres of molecular repulsion, set up a vibration whose velocity or pitch is measured by hundreds of millions, in the millionth part of a second:

When we examine other occasions of heat or molecular movement, we find the actions not dissimilar. Thus, in the case of *friction*, it is evident that the more prominent particles, pressed by either side between the rubbing surfaces, (not indeed by actual contact, but by what is equivalent, their repulsive spheres,) momentarily forced back within their repulsions and thereby compressing others, rebound with a vigor proportioned to the pressure; and thus, like a spring, continue an oscillation, strengthened and accelerated by the duration of the raspings. So, when a body is subjected to percussion, we see how a vibration must be started, intense in proportion to the violence of the blow, as well as to the reinforcement of repeated action. In the fire-syringe, the volume of air already possessing a quantity of molecular motion due to the ordinary temperature, suddenly compressed into a very small space, must of necessity have the velocity of its particles greatly increased, and consequently the frequency and violence of the repulsive collisions correspondingly aggravated and intensified.

A similar conception may be extended to the thermal, chemical, and magnetic effects of electric currents, whether excited by frictional or by chemical disturbance, although the precise nature of the molecular movements is undoubtedly wrapped in great obscurity.

As has already been indicated, all applications of animal power may obviously be regarded as derived (either directly or indirectly) from the static chemical power of the vegetable substance by which the various organisms and their capabilities are sustained; and this power, in turn, from the kinetic action of the sun's rays.

Winds and ocean currents, hail-storms and rain, sliding glaciers, flowing rivers, and falling cascades, are the direct offspring of solar heat. All our machinery, therefore, whether driven by the wind-mill or the water-wheel, by horse-power or by steam—all the results of electrical and electro-magnetic changes—our telegraphs, our clocks, and our watches, all are wound up primarily by the sun.*

The tides, with all their lifting power, (to which the largest ocean-

* The elder Stephenson, some fifty years ago, appears to have been the first to form the conception that his locomotive engines were really driven by solar power.

ships are as feathers,) and all their wearing action upon coast and river shores, are due partly to the sun's attraction, but in a much larger degree to that of the moon, an outlying portion of the earth's former equator.*

Not pausing to notice the various theories—more or less plausible—of chemical or of aqueous agency in earthquake waves and in volcanic ejections, we may, for the present purpose, regard these occasional outbreaks as the readjustments and vents of wide-spread pressure, from insensible settlings by the shrinkage of the earth's crust, resulting from the extremely slow cooling of the interior mass: the hardened envelope of stone or rock, a poorly conducting material, acting as a blanket which almost arrests the escape of the internal heat. And this heat, again, may be regarded but as a feeble residuum of that cosmical activity still notable in the sun and other stars.

Finding thus from observation that the sun is the great source of energy—static and kinetic—in almost all terrestrial phenomena, from the meteorological to the geographical, from the geological to the biological, we can only conclude that in the expenditure and conversion of *molecular movements*, derived from the sun's rays, must be sought the motive power of all this infinitely varied phantasmagoria. Thus, especially in the great store of *organic* force existing in the vegetable world, we must suppose that these subtle actinic vibrations, several times finer and higher even than those recognized as heat, have such relation to the molecular masses and inertia as by "forced" vibrations to overcome the powerful attraction of chemical affinities, and fairly to shake the particles into isolation, at the same time that other motions, photic and thermal, are expended in occluding in the plant structure the carbon thus deoxidized and divorced.

Tracing back these potent quiverings through the ninety-one and a half millions of miles of ethereal highway, along whose inconceivable

* Mayer, in his remarkable *Dynamik des Himmels*, discussing the retarding effect of the tidal wave on the earth's rotation by reason of friction, calculates that this is sufficient to have lengthened the day, within the last two thousand five hundred years, by one-sixteenth of a second. On the other hand, since the globe must have cooled somewhat within this period, (estimated at one-fourteenth of a degree Centigrade, or about one-eighth of a degree Fahrenheit, for the whole mass,) this would involve a contraction of the earth's radius (or a depression of its surface) amounting to about fourteen feet nine inches. Such a diminution of the equatorial leverage of rotation necessarily implies an acceleration of the motion, or a shortening of the day, very nearly equal to the opposite tendency, and counterbalancing it. "When our earth was in its youth its velocity of rotation must have increased to a very sensible degree, on account of the rapid cooling of its very hot mass. This accelerating cause gradually diminished, and as the retarding pressure of the tidal wave remains nearly constant, the latter must finally preponderate, and the velocity of rotation, therefore, continually decrease." (*L. E. D. Phil. Mag.*, 1863, Vol. XXV, pp. 409 and 427.) During the historical period, accordingly, it appears that the length of the day has reached its minimum, and has been sensibly constant or uniform, the rotation having greatly increased in the distant past, as it must as greatly decrease in the distant future.

essence they have so swiftly sped without the slightest loss,* we are brought at once to the great problem which has lately been so actively pursued—the origin of the sun's rays.

Assuming matter originally endowed with molecular attractions and repulsions, (regarding gravitation as resident in the primitive atom, though infinite in range,) and assuming such matter created in a state of power—that is, of extreme diffusion, or with its attractions wholly unsatisfied—we have all that is necessary to explain *dynamically* the existing order of nature. The great difficulty we have in forming satisfactory theories of the constitution of matter lies in the apparent complexity of the forces displayed. Thus we have at least five distinctly marked kinds of molecular attraction, each so characteristic that it cannot be converted into or mistaken for either of the others; and there are probably as many forms of repulsion. But starting with the idea of matter converging or falling together, we see how the encroachment of such a condensation on the repulsive spheres must give rise to a violent agitation; in short, to a heat vibration far more energetic or intense than any purely chemical action, by as much as the space-potential of gravity exceeds that of affinity; far more intense, indeed, than any temperature now probably existing in the sun.†

Here, then, in molecular gravitative attraction—as the ultimate resort, are we forced to accept the *primum mobile*—the origin of the power which has not only evolved and molded our solar family of worlds, but which has sustained our terrestrial economy in all the wondrous changes of its eventful career throughout the geologic ages. Beyond this fundamental conception of mysterious "attractions" forever resident in material elements, it does not appear probable that scientific research will be able to carry back the parentage or genesis of force. And yet there have not been wanting numerous hardy attempts to frame explanations and hypothetical antecedents of these postulated affections of atoms, or to replace them by dynamical agents or actions; while really leaving the problem of derivation as unsolved, or more insoluble than ever.

A laborious and ingenious French-Swiss physicist, Georges Louis Le Sage, about a century ago, devised the hypothesis that all space was occupied with extremely minute bodies, denominated by him "*ultra-mundane corpuscles*," moving in continuous right lines in all possible directions, with inconceivable but uniform velocity, and without collision

* The question is sometimes raised whether the light and heat of the sun and other stars may not be somewhat enfeebled or absorbed in passing through the celestial spaces. The doctrine of conservation of force teaches us that any absorption of either light or heat implies a proportionate amount of work being done, the consequenceof which would be a heating of *space* itself!

† A pound of coal falling to the sun from the distance of Neptune (which planet must be regarded as an ancient landmark of equatorial drift) would reach it with a velocity not very far short of four hundred miles per second; and the arrest of this motion would generate a heat vibration many thousand times greater than could be obtained from the combustion of the same pound of coal.

or interference; the total resultant of whose impacts on gross matter constituted gravitation. A single particle or mass of matter equally impressed on all sides by these universal projectiles would, of course, remain in perfect equilibrium. But two or more such bodies in space, screening each other on their facing sides, would be subjected to unbalanced impacts from these infinitely minute but powerful "corpuscles," and would thus be always urged toward each other in the directions joining their centers. No explanation of the origin of the enormous living force assumed in these winged motes was attempted. Although the law of the inverse square of the distance could be mathematically deduced from the assumption, the law of mass ratio was unfortunately not so well represented by it.

Sir John Herschel remarks upon this abstract speculation: "The hypothesis of Le Sage, which assumes that *every point of space* is penetrated at *every instant of time* by material particles, *sui generis*, moving in right lines *in every possible direction*, and impinging upon the material atoms of bodies, as a mode of accounting for gravitation, is too grotesque to need serious consideration; and besides will render no account of the phenomenon of elasticity"*

More recent speculators have supposed that *motion* explains everything; and they accordingly suggest the probability that all force—including gravitation—is a form of vibration. Observing the remarkable extension of the undulatory theory, first to light, and subsequently to heat, and perhaps mindful of the radiant law of diminution with the square of distance, they seem to have been led from this analogy to overlook the consideration that no vibration is possible without two opposing forces; and so in substitution or in explanation of that which is itself simple they proffer a duplex causation. All such hypotheses have been projected under the impulse of the ancient *à priori* dogma, that "matter cannot act where it is not," or of the equivalent proposition, that *action upon a distant body* is "inconceivable!"†

Professor Faraday entertained a somewhat indefinite idea (borrowed from Boscovich's abstract centers of force) that matter must be continuous, or everywhere present, in order that forces may be transmitted by virtual contact. He says: "Doubtless the centers of force vary in their distance one from another, but that which is truly the matter of

*"On the Origin of Force." *Fortnightly Review*, Vol. I, p. 438.

† It may be asserted in reply to this, that no scientific theory is final until its ultimate postulate is "inconceivable." "For if the successively deeper interpretations of nature which constitute advancing knowledge are merely successive inclusions of special truths in general truths, and of general truths in truths still more general, it obviously follows that the most general truth, not admitting of inclusion in any other, does not admit of interpretation. Manifestly as the *most* general cognition at which we arrive cannot be reduced to a *more* general one, it cannot be understood. Of necessity, therefore, explanation must eventually bring us down to the inexplicable. The deepest truth which we can get at must be unaccountable." HERBERT SPENCER, *First Principles*, (second edition,) Part I, Chap. IV, p. 73.

one atom touches the matter of its neighbors. Hence matter will be *continuous* throughout; and in considering a mass of it, we have not to suppose a distinction between its atoms and any intervening space. The powers around the centers give these centers the properties of atoms of matter; and these powers again, when many centers by their conjoint forces are grouped into a mass, give to every part of that mass the properties of matter."* And yet, in his earlier speculations, he says in regard to electrical action in a vacuum, "Suppose it possible for a positively electrified particle to be in the center of a vacuum an inch in diameter, nothing in my present views forbids that the particle should act at the distance of half an inch on all the particles forming the inner superficies of the bounding sphere."† This, as Dr. Müller has remarked, is certainly an admission of the dreaded *actio in distans;* but whether this view was subsequently modified is not very clear. Nor is it clear that Faraday, in affirming the presence of matter wherever it acts, had any other conception than that usually entertained by those who accept the atomic theory. To assert that our moon "touches" the earth, nay, that it embraces Neptune, notwithstanding its perfectly determinate boundary of material surface, is only to employ words in a wholly unintelligible sense. To affirm an infinitude of material interpenetrations is simply to ask the adoption of a new term instead of "matter," to represent that bounded *something*, or congeries of somethings, which all experimental research attests to be impenetrable.

Professor J. Challis, of the University of Cambridge, England, has proposed "A Theory of Molecular Forces," which he has presented in a refined mathematical exposition, in a series of essays published in the *Philosophical Magazine*, from 1859 to 1871;‡ and which, assuming the molecules of matter to be surrounded by a continuous ethereal medium of uniform elasticity pervading all space, resolves all forms of force into the *pressure* of this ether; each atom being the center of vibrations propagated from it equally in all directions.

Dr. Balfour Stewart, in an essay on "The Dynamical Theory of Heat," appears inclined to favor a somewhat similar view. He remarks: "Till we know what the ultimate nature of matter is, it will be premature to speculate as to the ultimate nature of force; though we have reason to believe that it depends upon the diffusion of highly attenuated matter throughout space."§

Professor Frederick Guthrie, in a paper read before the Royal Society of London, in 1870, "On Approach caused by Vibration," detailing some very interesting experiments showing small converging aerial currents resulting from tuning-fork vibrations, (in perfect accordance with the

* *L. E. D. Phil. Mag.*, February, 1844, third series, Vol. XXIV, p. 142.

† *Experimental Researches in Electricity.* Reprinted from the Phil. Trans., 1831–1838. Series xiii, sec. 1616, Vol. I, p. 514.

‡ *L. E. D. Phil. Mag.*, fourth series, Vols. XVIII, pp. 321 and 442; XIX, 88; XX, 280, 431; XXI, 65, 92; XXIII, 313; XXVI, 280; XXXI, 459; and XLI, 280.

§ *North British Review*, February, 1864; (Vol. XL, page 22, American edition.)

mathematical theory of hydrodynamics,) thinks he finds in these phenomena an explanation of force in general, including that of gravitation. He observes: "In mechanics—in nature, there is no such thing as a pulling force. * * * The line of conclusions here indicated tends to argue that there is no such thing as attraction in the sense of a pulling force, and that two utterly isolated bodies cannot influence one another. If the ethereal vibrations which are supposed to constitute radiant heat, resemble the aerial vibrations which constitute radiant sound, the heat which all bodies possess, and which they are all supposed to radiate in exchange, will cause all bodies to be urged toward one another."* Supposing that such resulting ethereal currents could have any sensible influence on planetary masses, it seems to be entirely overlooked that such currents would be of the most variable and fitful character. Every sun-spot would derange the planetary orbits; planets when cloud-clad would affect each other very differently from those having transparent or diathermanous atmospheres; and no resource of mathematics could ever predict an occultation or eclipse.

Were it necessary to discuss the question whether gravitation is either a form or a result of *motion*, the fact that its action is instantaneous, that it requires no sensible lapse of time to be felt by the most distant planet, is perhaps the most direct evidence bearing on the point. Were any interval of time occupied in the transmission of this influence from the sun to a planet, there would result a phenomenon of "aberration" (similar to that of light) by the amount of orbital motion occurring during the time of its transit, the consequence of which would be an acceleration and extension of the radius-vector, or a spiral *unwinding* and final dispersion of all the planets and their satellites. In general terms, the stability of a planetary system, or the conservation of mean distances, depends upon the absolutely *radial* and *immediate* action of the central attraction. Supposing, in the case of our earth, that gravity occupied even so short a time as the hundredth part of one second in passing over the ninety-one and a half million miles from the sun—during this interval (of the one-hundredth of a second) the planet would have traveled about one thousand feet in its orbit; and the resulting displacement or "aberration" of directive force would be about the twenty-five-hundredth part of one second of orbital arc. It has been shown that even this small deviation would have been noticeable in the two thousand years separating us from the time of Hipparchus. Arago has estimated that any possible *velocity* of gravitation must be, at least, fifty million times that of light!†

Gravitation, therefore, is not a motion; nor is it the product of any motion. We are forced to the conclusion, however "unable to conceive" the fact, that it is really an *actio in distans*, and that *ad infinitum*; that it is a force, a faint reflex of its Author, *instantaneously omnipresent*.

* *L. E. D. Phil. Mag.* for November, 1870, Vol. XL, p. 354; and June, 1871, Vol. XLI, p. 406.

† *Popular Astronomy*, English edition, Vol. II, p. 469.

In the peculiar phenomena of magnetism, we have reason to believe that the attraction (as in the cases of gravitation, cohesion, and affinity) is resident in the ultimate molecules, if not in the constituent atoms. However minutely we may subdivide a magnetic bar of steel or nickel, (cobalt or manganese,) we cannot separate the poles—the attractive from the repellant. However small these fissiparous segments, each is itself a perfect magnet, with equal opposite polarity.

It is evident that the arrangement of the molecules in a magnetic bar, all axially accordant in direction, must be one of constraint, since although a single line of such particles would find a stable equilibrium in that uniform direction of polarity which should satisfy the attractions of all their contacts, yet a second adjacent line, similarly directed, would constantly present to the first line the antagonism of connatural or homogeneous poles. Hence, to secure a general stability of equilibrium, the supposed lines of molecular magnets should be alternately reversed. But such an arrangement would result in a complete neutralization of the attractive and repulsive forces, and the mass or bar of metal thus constituted, possessing no internal differential resultant, would exhibit no traces of integral polarity or magnetism.

Assuming (as we have reason from various considerations to believe) that in all solids the constituent particles, however firmly locked by their cohesive forces in their fixed relations of distance and position, are yet capable of rotation within their magic spheres, without affecting their solidarity, we can easily perceive how, under the attractive induction of a powerful external magnet, a bar of iron constituted as just suggested would have at once its constituent molecules polarized in direction, and thus become a sensible magnet, while it would as quickly relapse from this condition of restraint on the removal of the controlling agency. The actual behavior of iron is exactly conformable with such an organization. The entire efficiency of the electro-magnet for the purpose of telegraphy depends upon this property of facile molecular rotation in the iron magnet, whereby it instantly becomes spontaneously *de*polarized on the suspension of the electric current.

Under the quaquaversal disposition of the molecular axes, thus shown to be the normal condition of equilibrium, it follows that the magnetism of matter, however powerful, should remain forever latent, and all its manifestations in abeyance, did not some potent interference disturb this neutrality.

If, however, we further assume that in very rare cases, as in that of nickel or of hardened steel, a considerable amount of adhesion (the nature of which we are unable to comprehend) exists between the constituent particles, preventing their easy rotation, then we can perceive that the presentation of a powerful external magnet to such a bar would not easily or at once induce a sensible magnetization. If, however, the solicitation of the attracting magnet were sufficiently powerful, and sufficiently continued, to overcome the resistance of this molecular

adhesion, we can also perceive that the particles, when once brought into a common polarization, would be likely to maintain their constrained axial position permanently, provided that the adhesive resistances of the molecules should exceed their magnetic resistances. Such a behavior we find presented by hardened steel, to which habit the name "specific coercitive power" has been given.

There is obviously no transfer of virtue from the magnetizing to the magnetized body. On the contrary, the former is actually strengthened by its evolution of the manifestation in the latter—a result in perfect accord with the supposition of a reaction of *mutual* preëxisting attractions.

It is familiar that by holding a bar of steel in the direction of the earth's magnetic pole, or rather of its magnetic dip, and giving the end of the bar a few taps with a hammer, we can at once induce the magnetic condition. Here obviously the molecular vibrations from the blow have facilitated the rotations necessary to bring the particles into axial accord.

The work expended therefore in developing the magnetism of a steel bar, whether by the mechanical passes of an artificial magnet, the long-continued induction of the terrestrial polarity, or the molecular disturbance of an eletrical coil, is simply that required to overcome the original resistances to the changed condition. The magnetic force, or dual forces, must be regarded as primitive, constant, unchangeable attributes of the ultimate particles of matter; as incapable of increase, of diminution, or of transfer, as gravitation itself. And the notable discovery of *diamagnetism*, by Faraday, leads us to believe that all matter has this polar quality indelibly stamped upon it in varying degrees; the molecules of nitrogen possessing it in the smallest degree of any known element.

Analogical reasoning would appear to justify the conclusion that *electrical* attraction and repulsion (capricious, ephemeral, and mysterious as they appear) belong to the same category of original and unalterable molecular properties, although it is by no means easy to give so rational an account of the phenomena observed as in the case of magnetism. The fact that both are *polar* forces, exhibiting a duplex action; that in both cases similar states or poles repel each other, and opposite states or poles attract each other; that these conditions of attraction and repulsion apply equally or indifferently to either pole; and that an opposing polarity may be induced by approach in other matter, would certainly indicate a very similar nature and seat of influence.

In the apparent transfer, however, of electricity by contact or discharge, and in the neutral equilibrium immediately resulting, there is an action *sui generis;* as also in its manifestation as a differential of chemical, or of thermal activities. In the mutual reactions of the magnet and the electrical current, still more puzzling phenomena are presented; and without attempting to discuss Ampere's ingenious theory of the "solenoid," the observed fact that each does exhibit a torsional or tangential

action upon the other is one which has no parallel or analogue in any other of the known natural forces. In the quasi-magnetic behavior of electrical currents, whatever the vehicle or electrode, occurs a further extension of the same peculiarity.

Notwithstanding all these difficulties, and the intimate relations of "dynamic" with so-called "static electricity," a more comprehensive and rational theory of this most abstruse subject may hereafter establish as radical a distinction between the molecular movements constituting electrical currents, and the molecular capacities of polarity, or of electrical attraction and repulsion, as has been found to exist between light or heat and chemical affinities or molecular repulsions.

Nor is the inference here suggested affected by the fact that Joule, in 1843, derived his first approximation to the mechanical equivalent of heat from experiments "on the calorific effects of magneto-electricity,"* any more than it is by the fact that we accept terrestrial gravity, at the earth's surface, as the standard of comparison for all forms of energy.

It was seen at the outset that the conditions of antagonistic molecular attraction and repulsion, such as we find in the actual constitution of matter, were essential postulates to the theory of the conservation or persistence of force. We have been led to the conclusion that these same antagonistic principles constitute equally the real, efficient *origin* of force. And though we are provided with no general term to embrace these primordial, indestructible, immutable, statical centers of force, and to distinguish them from those other derivative, evanescent, and convertible forms of energy, exhibited either in the potential of constrained position, or in the actual of changing position, yet the two classes appear to be so essentially dissimilar that it may well be doubted whether the language very frequently employed by writers to express the correlations and transformations of material forces is really an accurate statement of the fact.

If it be true that all phenomena of energy may be traced back ultimately to molecular attractions and repulsions as their primeval parents, and if these same attractions and repulsions are found to be persistent, ever-present, and unexchangeable, however frequently matter in its protean character may be shifted (so to speak) from the active dominion of the one to that of another, it would seem to be exceedingly improbable that, conversely, any form of molecular attraction or repulsion can be produced or derived from motion, or from the ordinary manifestations of dynamic energy.

If this be so, we are not warranted in speaking of the correlations of gravity, of cohesion, of chemical affinity, and of magnetism, in the same sense in which we apply the term correlation to the secondary or convertible forms of force, as among themselves, and as connected with their primaries.

* Mr. Joule's paper, read before the British Association, August, 1843, was published in the *L. E. D. Phil. Mag.* of that year, Vol. XXIII, pages 263, 347, and 435.

INDUCTION AND DEDUCTION.

A DISCOURSE BY JUSTUS BARON VON LIEBIG.

DELIVERED IN THE ROYAL ACADEMY OF SCIENCES, MUNICH.

(*Translated for the Smithsonian Institution.*)

The ideas of the generality of men respecting the nature of scientific research are so imperfect and erroneous that it will not, perhaps, be without interest to many if I attempt to elucidate and complete the views which I advanced on this subject in a former discourse on Francis Bacon, of Verulam.

Philosophers pursue in general two methods of inquiry in regard to the phenomena or laws of nature, induction and deduction; they are in effect but different processes, while their object is the same; the distinction between them depends upon the point of outset; the deductive method sets out from generals, the inductive from particulars; in the combination of the two induction precedes deduction.

The nature of induction, according to Aristotle's view of it, may perhaps be best illustrated by the example which he himself gives of an inductive conclusion:

Man, the horse, the mule, &c., live long.
Man, the horse, the mule, &c., have little gall.
Therefore, all animals that have little gall live long.

This mode of conclusion, if so we must call it, is a very easy one to the inquirer; but what is here styled a conclusion is only the observation of the juxtaposition of two phenomena; scarcity of gall is a fact which accompanies long life; it is part of a whole, and the conclusion no syllogism, including in itself the reason of the dependence of longevity on the paucity of the secretion in question. We need only substitute in the middle term, instead of gall, any other simultaneous fact peculiar to certain animals, for instance:

Horses, mules, &c., live long.

Horses, mules, { have little gall.
have glycose in their muscular tissues.
have no uric acid, (*Harnsäura.*)
have (Hippursäura)

in order at once to perceive that the connection of these with longevity is purely arbitrary and rests on no operation of the understanding. The philosopher, for the explanation of a phenomenon of nature or of a process, seeks to assign a connection between the parts thereof which have come under his observation, and first of all sets out with the supposition, as regards two facts which constantly accompany the phenome-

non or process, that they postulate one another, or that one is dependent on the other; but this is merely an idea having no real basis for its support, but simply a perception which may or may not arise in the mind of any one.

Aristotle denoted induction as being the passage from particulars to generals, since, in physical inquiry, our first concern is with the knowledge of the phenomenon and afterward with its explanation; but in this sense it is clear that he regarded induction not as a *method*, but as a *rule* of investigation.

It is plain that if all the forces of nature and their laws were known to us, if we knew all things in their nature, action, and properties, the investigation of a particular process and its explanation would be a simple deductive problem; each single case would then be soluble through a conclusion of the understanding. Suppose, for instance, that the rusting of iron in the air were the point to be explained; the previous examination of rust has determined that it contains iron, oxygen, and water; the composition of air is also known; the elements, therefore, for explaining the process of rusting are before us, but further inquiry shows us that iron in oxygen in the presence of the vapor of water does not rust; there must, then, be some constituent principle of the air, besides oxygen and vapor, in order that iron should undergo the process of rusting; now we know that the air actually contains a very small portion of carbonic acid, and examination shows that a mere trace of carbonic acid suffices, with sufficient access of oxygen, to convert a large mass of iron into oxide; but the rust itself contains no carbonic acid. The question then is: What part does this acid play in the process? Another known fact now suffices to complete the explanation; this is the action of the oxidulated carbonate of iron; in damp air it attracts oxygen and is converted into the higher oxide which enters not into combination with carbonic acid; it is by the rusting of the metal that the lower oxide first originates, and this combines with carbonic acid, which through the passage of the oxidulate into free oxide becomes capable of exerting in a hundredfold degree its original action on the metal, so that gradually the whole piece is throughout converted into iron-rust. Inquiry further establishes that there is a special case where iron in damp air, even without the presence of carbonic acid, is thus rusted, when the air, namely, contains ammonia; but that in that case the rust does not extend, and that, lastly, an electrical process is coöperative with the rusting.

To this class of investigations belongs also that of the production of dew by Dr. Wells. That dew is a watery precipitate produced by refrigeration admitted of no doubt, nor that the modes of refrigeration were only two. The problem only turned upon the question, whether the conditions of the cooling were dependent on conduction or on radiation, which point was susceptible of determination by experiments guided by known laws.

To inquiries of this sort no exterior difficulties oppose themselves, and, for conducting them, knowledge and the correct appreciation of relations abundantly suffice; they rarely occur, because the physical inquirer, for most of his problems, does not find ready prepared the thought-material requisite for his mental process; it should also be remarked that by these our insight into the nature of phenomena is indeed rendered clearer and more thorough, but that the boundaries of science are not thereby enlarged.

In the great number of other inquiries, the inquirer is confronted by obstacles which, with the whole stock of knowledge furnished by science and with the most perfect powers of discrimination, he cannot remove, and these are new facts or phenomena which pertain to unknown laws, which are not accessible to the understanding from a deficiency of the intervening facts necessary to his ideas. For this class of inquiries there must coöperate, in the case of the philosophical inquirer, something which essentially characterizes his mind, and that is the force of imagination.

The sum of what we know respecting nature and its forces is, in fact, so small when compared with what we do not know respecting them, that the physicists of our times find themselves, in a majority of cases, precisely in the condition of those of the sixteenth century as regards those things which to them were unintelligible but to us are easy; there is for us, as there was for them, a defect of clearly comprehensible facts essential to the deductive process; in the failure of a single one of these the intellect stands before a chasm which it cannot fill up; in that earlier time the force of imagination was called in aid to an extent which we regard now as wholly inadmissible. The advantage we have over the early inquirers rests therefore not on increased intellectual powers or on the superior delicacy and penetration of our senses, but on a greater affluence of facts or experiences, that is, on an accumulation of materials for the operations of the understanding. Hence there is no doubt to be raised respecting our relative position; and yet there are but few who have a clear idea of the sources from which the constantly increasing store of these materials for thought is derived.

If we cast a glance backward on the history of the so-called inductive sciences, we at once recognize that for centuries they had the character of an art. Until Newton, astronomy and mechanics were arts; the same were physics until the time of Galileo; and chemistry up to that of Bergmann. Bœrhaave defines chemistry as the *ars docens exercere certas physicas operationes.*

Art and science are essentially distinguished from one another by their different aims.* That of art is the search for or the finding of facts;, that of science is the explanation of them. By art, of course, we do not here mean any of the fine arts. The artificer seeks to attain an object; the experimental artificer seeks a thing. From particu-

* The aim of art is the discovery of facts; that of science the discovery of principles and laws.—J. H.

lars he would construct a whole. The man of science, on the other hand, seeks a reason or principle. From the whole he proceeds by its parts, even to the roots. As the artificer knows nothing of a principle, and a principle would be of no help to him, it will be understood that the process going on in his mind is no intellectual operation. The intrinsic character of his thought resides in this, that he thinks of sensible phenomena. As the understanding examines ideas, measures, as it were, determines and fixes their import, so that they become serviceable for deductive operations, just so does the inductive artificer proceed. He probes the phenomena with all his senses, and while he applies his faculty of perception, with all the tension of his will, to one property of a substance or one pecularity of a phenomenon after another, to the present exclusion of all others, his imaginative power acquires a sharp and definite image of the whole thing, which, like an abstract idea, includes in itself the entire essence of the substance or phenomenon. A blue, black, or yellow color, or the existence of a white precipitate which is soluble or insoluble in a certain acid or alkali, calls up in the mind of the chemist the idea of iron, iodine, kali, magnesia, sulphuric or muriatic acid, &c., an ideal iron, iodine, &c., altogether different from the conception which men in ordinary life connect with those substances.

The understanding arrives, through the combination of exact ideas, at conclusions whose truth is only intellectually discernible; the mental combinations of the artificer, on the other hand, are material or capable of being represented to the senses.

In this peculiar mental process, in which the imaginative power plays the principal part, consists essentially the idea which I should be disposed to connect with the word *induction*, and I do not think that it is in conflict with that of Aristotle.

It is not easy to convey a clear idea of the nature of the mental operations of the experimental artificer, which, as already said, depend on a combination of facts or phenomena standing in a similar relation to one another, with the logical ideas which guide the understanding in its conclusions; from the facts or reactions known to him he determines respecting the existence of a new one before unknown; his conclusion is again a fact or a reaction; perhaps it is to the peculiar faculty of the musical composer, who thinks in sounds, that the process of chemical or physical thinking may be most closely compared.

In exact research, the logic of the explanation of a phenomenon or demonstration of a problem, rests on facts, which hang together as by the links of a chain, or as by hinges, and whoever will take the trouble to revise a chemical or physical investigation, will at once perceive that a majority of the facts which serve the philosophic inquirer for an explanation or demonstration, do not offer themselves in nature, but that they are first excogitated or devised by the inquirer himself; he is necessitated to seek out the facts which are wanting to his mental oper-

ation or deduction by means of induction, that is, through the combination of his conceptive or imaginative faculty; and his labor consists in this, that, in conformity with the rules of experimental art, he shall call into action the mediums or the substances which seem adapted to his purpose, and from the reactions or phenomena which come to light, draw a conclusion as to the existence or non-existence of the fact sought for; he contrives, it may be said, a series of trials, which, in their final result, give the direction to his deduction.

The difficulty lies for him herein, that the route to the fact he is seeking is to him completely unknown; for were it known, the conclusions of the understanding would lend themselves to his aid. He is, therefore, necessitated to abide entirely by the phenomena which his tentatives furnish him, since these are the characters which guide his imaginative power in its combinations.

The remarkable discovery of ozonized oxygen in a chemical way by Schönbein, affords one of the simplest examples of inductive processes. Schönbein had found that, by the transmission of electrical sparks, the atmospheric air acquires new properties, of which the most remarkable consists in a powerful combination faculty of its oxygen, till then unknown; in such air a number of bodies (silver, for instance) are oxydized, on which the oxygen in air not electrified is without any influence. Now, how came Schönbein to conclude thereupon, that phosphorus, by being slowly burned in air, would bring about the same condition in the air as did the electric spark? This conclusion was based upon the fact that the air after electrification and after contact with phosphorus smelled precisely alike; the scenting principle in the air, at the same time, had been found by Schönbein to produce the same effects. The similarity of a sensible property, of a scent, led therefore to the inference of the origin and existence of a like substance, ozone, in two processes in their nature entirely different. In this combination of ideas, had the guidance been left to the understanding, it is highly probable that the discovery would have been impeded by it; for to the understanding the fact of the origin of a substance endued with the highest oxydizing powers, through or near a body which, like phosphorus, is in the highest degree oxydizable, would have appeared wholly improbable.

One of the most important of Faraday's discoveries furnishes an example of a more complex induction.

Oersted had, through an electrical current, induced magnetism in metallic conductors; the problem which Faraday proposed to himself was, the reverse, to generate by means of a magnet an electrical current; it was directed to the production of a phenomenon, and since its law and the way to its discovery were unknown, could only be solved in the experimental, that is, in the inductive manner. The phenomenon once known in all its relations, could then first become the subject of a deductive scrutiny, and the contrast of the inductive labor of Faraday

and the deductive labor of Weber is here quite apparent. Faraday sought, if we may use the expression, the *thing;* Weber the *principle* or the *law.* I have heard mathematical physicists regret that Faraday's treatises on such subjects were, in point of style, nearly unintelligible and scarcely readable, and that their tenor much resembled an extract from a day-book; but the fault was in themselves. Upon physicists who have advanced by the way of chemistry to physics, Faraday's treatises make much the impression of wonderfully fine music.

The discovery of the electrical machine, the electrophore, the Leyden jar, the voltaic pile, as well as of the three laws of Kepler, has been achieved through the combinations of the imaginative power; and so it is also with the procedures for the extraction of metals, which, as that of iron from iron-stone, of silver from the lead ores, and of copper from the copper ores, are among the most complicated of processes. The conversion of iron into steel, of copper into brass, the transformation of hide into leather, of fat into soap, of common salt into soda, and a thousand similar important inventions, have been made by men who had no idea, or a wholly false one, of the proper nature of the things or processes to which they directed their powers of ideal combination.

The understanding has not the least to do with the combinations of ideas which have carried the manufacturer of glove leather to the towers of the city in order to collect for his purposes the white excrement of daws and rooks, or which have led the dyer to employ that of the cow for fixing on stuffs his mordants and colors, or which, on the lofty plains of America, so poor in combustible material, prompted the miner to the singular expedient of obtaining silver in the wet way. All this will undoubtedly appear remarkable enough when it is remembered that until a few years past, the proper nature of glass, soap, and leather was unknown, and that researches are still daily made to determine precisely the reactions which take place in the melting-oven during the soda process.

As a last example of the inductive procedure in technical processes I will select the lately discovered art of producing light-images—processes, however, which have not yet found an explanation. The facts which lie at the foundation of photography are two: The one that the salts of silver (the chlorine, bromine, iodine of silver) are rendered black by the light; the other that the unblackened combinations of silver are soluble in sub-sulphurated natron, so that the blackened and the unblackened may be separated from one another by means of this salt.

These two facts formed the starting point of the experiments of Daguerre in Paris and of Talbot in London; the first sought to produce images on silvered copper-plates, the other on paper. When, in the camera obscura, an image of a tower or of a house, for instance, is thrown on paper overspread or saturated with chlorine or iodine of silver, there arises in Talbot's experiments, after some hours' exposure to the operation of the light, a corresponding image; the more lustrous

places become, in proportion to the strength of the light, blackened into corresponding shadows; the obscure places remain white or luminous. The sashes of a window, for instance, throw less light on the paper than the glass panes; a dark stone less than the bright stones. Whatever is dark in the object appears bright; the bright, dark. There is impressed on the paper a so-called negative image. If the paper be now washed with a solution of sub-sulphurated natron, so much of the chloride of silver as is unchanged by the light is removed; had this remained on the paper the image would by degrees become black, under the operation of the light, and again disappear. The salt mentioned is therefore the medium through which it becomes fixed.

The first images presented by Talbot were very imperfect; as their production required a long exposure to the operation of the light, only the images of perfectly immovable objects could be obtained. The experiments of Daguerre gave occasion to the perfecting of Talbot's procedure, but in a singular manner. Daguerre exposed his silvered plates to the influence of the vapor of iodine, and in this way gave them an extremely thin coating of silver of iodine; but from this resulted no image in the camera obscura. Months of trials, varied in all manner of ways, afforded no results. At length hazard, in the most proper sense, came to his aid; Daguerre had put aside a number of the plates which had served for his experiments in an old press, where they remained for weeks without further attention. Happening on some occasion to take one of them out, he saw, to his utmost surprise, an image traced upon it, of the greatest distinctness to the minutest particulars. No idea had he how it was produced, but, of course, there must be something in the press which had brought to light the image on the plate. Now, there were all sorts of things therein: Utensils, apparatus, chemical reagents, and, among the rest, a vessel containing quicksilver. Daguerre proceeded to remove one article after another, overlooking, however, the quicksilver; and he still procured images whenever he allowed one of the plates, on which he had thrown an image in the camera obscura, to remain some two hours in the press. Of the quicksilver he did not think; the old press had begun to appear to him an enchanted press. At last it occurred to him that the image must proceed from the quicksilver, and it turned out to be what may be called a breath picture. If a drawing be made with a wooden pencil on a clean glass plate, the sharpest sight will fail to discover the lines, which nevertheless become distinguishable when the places marked by the pencil are breathed upon. There exists, in effect, in these places and other parts of the glass an unequal condensation of the watery vapor which is deposited thereon in fine drops.

In this manner Daguerre's images originated. Quicksilver is volatile, and its vapor had been diffused through the press and settled in minute drops on the plates, taking effect more strongly on the more illuminated parts, so that the outlines and shadings of all objects were rendered

clearly visible. I do not propose to enter here into the improvement of the optical apparatus, nor to explain how the fugitive images of Daguerre were, by gilding in a chemical way, rendered stable and unalterable, but I return to the images on paper and will first speak of the influence which the Daguerrean discoveries had upon Talbot's undertaking.

Daguerre had found that the effect of the light exerted for a second on his prepared plates sufficed, through evaporization with quicksilver, to bring out an image. As Talbot had on his paper the same preparation as Daguerre on his plates, he inferred that on the paper also, by a second's illumination in the camera obscura, the sun must have produced an impression; he was convinced that an image was present on the paper, though not a trace of it was to be seen. This conviction impelled him to seek for some medium through which the figure might be brought out; there must be something, he thought, by which this could be effected. Now, how came Talbot to employ a solution of gallic acid for this purpose?

Most persons, perhaps, would be disposed to allege here, as in Daguerre's case, the intervention of hazard, but the choice of gallic acid was no accident. Daguerre had placed the vessel containing quicksilver in the press with no view to experiments; his images were produced through no agency of his. Talbot, on the other hand, applied himself to the research for means of accomplishing a definite object, and among so many thousand substances his imaginative faculty naturally rejected all those which stood in no relation to that object, and dwelt only on those which produce an effect similar to that of light. Now, light and warm gallic acid blacken the salts of silver; the effect of both is identical, but that of gallic acid much the stronger. The sun's light had, in the camera obscura, produced an effect on the prepared paper, but one too weak to be perceptible; perhaps it might, as he argued, be brought out and strengthened by gallic acid. The trial succeeded, and the correctness of the induction was thereby vindicated.

From these examples the nature of induction ought to be intelligible to every one. It will be remarked that an acquaintance with the principle of the processes, *how* light and gallic acid properly act upon the salts of silver, *whereon* the solution of these salts in sub-sulphurated natron depends, was for Talbot's as well as for Daguerre's purpose perfectly indifferent.

For those persons who have no acquaintance with the ideal combinations of the imaginative power, they naturally do not exist, and such are for the most part prone to ascribe to chance discoveries which proceed from the most sagacious inferences of the faculty. Chance has indeed its own part therein, since the elements for the determinations of the understanding are so frequently offered to it by so-called accidental circumstances. But the fact that experimentation must be learned; that it has its rules and is an art, and that their results presuppose a very widely ranging acquaintanceship with facts or sensible phenomena,

teaches us that it rests on a properly intellectual labor, in which the understanding participates as a useful counsellor and assistant, but without guiding it and without its being dependent thereupon.

In science, as well as in common life, the operations of the mind are executed not according to the rules of logic, but the conception of a truth, the idea of a process or the cause of a phenomenon, generally precedes the demonstration; the conclusion is not reached through the premises, but the conclusion goes before, and the premises are then first sought out as proof. In a conversation with a celebrated French mathematician, on the part which the imaginative faculty bears in scientific labors, he expressed himself to the effect that by far the greater number of mathematical truths are obtained, not by deduction, but through the inventive or imaginative power, and in this he had a view even to the properties of the triangle, the ellipsis, &c., which is saying little else than that the mathematician, as well as the physicist, can do nothing for his science without artistic endowment.

It is scarcely necessary to say that for deductive as well as inductive research, if any results are to follow, a certain extent of information is prerequisite; for the deductive research, a well-grounded knowledge of laws already discovered, to which previous reading and books are contributary; for inductive, a comprehensive acquaintance with material phenomena which is to be acquired in chemical, physical, and physiological laboratories. As schools, these last are a modern creation, and their influence in the development of all departments of physical science is, to the reflecting observer, a thing not to be questioned.

To an acquaintance with sensible phenomena or the knowledge of the nature and action of things, must be united in the case of the inductive inquirer, if he would duly resolve the problems presented to him, a memory for sensible phenomena, a memory, it might be said, of sight, taste, and smell, together with a certain degree of artistic expertness and dexterity. The broader and more comprehensive his knowledge of facts and phenomena, or, as it is usual to say, the greater his experience, so much the more will his labor be lightened; an experienced man makes much fewer experiments than the inexperienced, who must make himself acquainted with many phenomena which to the other are already familiar; to the former, indeed, for the attainment of many ends, numerous experiments would be superfluous, since the combination of processes and facts already within his knowledge, abundantly suffices.

In the solution of their respective problems, the deductive and inductive inquirer begin in the same manner; the one, like the other, starts from a complex idea of the understanding or the imaginative power, of which in general only a part is true, while the other parts rest on erroneous inferences or combinations. The deductive inquirer tests and experiments with intellectual conceptions in order to find the truth, just as the inductive inquirer does with sensible ideas in order to find the thing sought for; both, in the prosecution of their inquiries, strip away,

by testing and improving, what is false, and detect the parts which are wanting to complete the idea submitted to examination. The idea from which they set out is not unfrequently wholly false, and the true is first sprung in the course of the investigation. Hence, the doctrine of many of the greatest inquirers that the labor is everything, and that any theory may lead to truth, provided it gives the impulse to toil.

In deductive inquiry, it is the conviction of the correctness of a concluding idea (*schluss-idee*) which stimulates the understanding of the inquirer to its appropriate activity; and so with the experimental artificer, the conviction of the existence of a thing is the first and most efficacious incitement to the movements of the imaginative power; the discovery of a new fact or reaction, to which the idea of something before unknown, something useful or important for industry or life, attaches, is sufficient to awaken the conviction of its existence in many individuals, and it not unfrequently happens that it is in reality simultaneously discovered by several.

Understanding and imagination are alike necessary to our knowledge, and in science are alike authorized; they both have an allotted part in all problems of physics and chemistry, of medicine, of public economy, history and philology, and comprise each a certain space in its appropriate province. The part in which the imaginative faculty bears sway is proportionately wider and more comprehensive, as the positive knowledge with which the understanding circumscribes it is more indeterminate and indistinct. Progress consists in this, that with the increase of knowledge, the conceptions which have sprung from the imagination vanish, and while in the first periods of science this faculty had undisputed ascendancy, at a later stage it subordinates itself to the understanding and becomes to the latter a helpful and willing servant.

Induction under the guidance of the imagination is intuitive and creative, but vague and extravagant; deduction under the guidance of the understanding analyzes and limits, and is definite and measurable.

One of the most essential characters of deductive inquiry in science is *measure*, and the ultimate aim of all its labors is directed to an unalterable numerical expression for the properties of things, for processes and phenomena. Imagination compares and discriminates, but measures not, for measurement implies a scale, and that is a product of the understanding.

By the introduction of science into an art accrues an advantage, scarcely enough appreciated; that science abolishes art as such, and what is individual in it, while resolving it into rules which may be taught and learned; through a knowledge of which rules even the unproficient in business, industry, husbandry, and technics, is invested with the power of the most proficient, most skillful, and most experienced practitioner, who attains his aims by the shortest, surest, and most economical means. What before was proper to the individual becomes thenceforth the joint property of all.

ADDRESS ON THE RELATION OF FOOD TO WORK, AND ITS BEARING ON MEDICAL PRACTICE.

By Rev. Samuel Haughton, of Dublin.

Mr. President and Gentlemen: Man, like other animals, is born, grows, comes to maturity, reproduces his like, and dies, passing in his lifetime through a cycle of changes that may be compared to a secular variation, by a metaphor borrowed from the science of astronomy; while in his daily life he passes through a smaller cycle of changes that may be called periodic.

From the time of the publication of Bichat's celebrated Essay on Life and Death, it has been admitted that man and other animals possess a double life, animal and organic, presided over, respectively, by two distinct though correlated centers of nervous force; of these, one thinks, moves, and feels; the other merely cooks, receiving the food supplied, changing and elaborating it into elements suitable for the use of the animal life. In the lower forms of animals the organic life becomes almost coextensive with the whole being of the creature, which simply digests, assimilates, and excretes, but barely feels or moves; in the higher forms of animals, and more especially in man, the animal life dominates over the organic life, which becomes its slave, and exhibits the remarkable phenomena of mechanical force, of geometrical instinct, of animal cunning, and, finally, in man himself, produces intellectual work, rising to its highest form in the religious feeling that recognizes its great Creator, and bows in humility before Him. It is a simple matter of fact, and of every-day observation, that all these forms of animal work are the result of the reception and assimilation of a few cubic feet of oxygen, a few ounces of water, of starch, of fat, and of flesh.

The general question of the relation of food to work would involve a consideration of the possibility of throwing a bridge across the gulf that separates the organic from the animal life, so as to connect the products of nutrition (taken in its widest sense) with the work of every kind accomplished by the animal life, whether mechanical or intellectual. We resemble the spiders of the heather on a summer morning, that float their gossamer threads into the air from the summit of a branch, in the hope that some stray breath of wind may fasten them to a neighboring tuft, and enable the hungry speculator to extend the range of his rambles and his chance of food. Already a few feeble threads connect the chemistry of our food with the mechanical work done by our muscles; when these shall have been securely fastened, from the higher vantage

ground thus acquired, our little bridge of knowledge may possibly be extended to embrace the phenomena of the geometrical instinct of the bee, or the cunning of the beaver, and our successors may even dare to speculate on the changes that converted a crust of bread or a bottle of wine, in the brain of Swift, Molière, or Shakespeare, into the conception of the gentle Glumdalclitch, the rascally Sganarelle, or the immortal Falstaff. At present such thoughts would be justly regarded as the dreams of a lunatic, and I must crave your indulgence for having mentioned them. The history of science is, however, filled with such dreams—some never realized, others converted by time into realities so commonplace that the genius of their originators is habitually forgotten or underrated.

During childhood and youth the food that we eat is used for the double purpose of building up the tissues of the bones, muscles, brain, and other organs of the body, and of supplying the force necessary for work done, whether mechanical or intellectual. In adult life the first use of food almost disappears, for the bones, muscles, brain, and other organs have already reached their full development, and act simply as the media of communication between the food received and the work developed by it.

Let us take, as illustrations, the muscles and brain, regarded as the organs by means of which mechanical and intellectual work is done. These organs resemble the piston, beam, and fly-wheel of the steam-engine, and, like them, only transmit or store up the force communicated by the steam in one case, and by the products of the food conveyed by the blood in the other case. The mechanical work done by the steam-engine must be measured by the loss of heat experienced by the steam in passing from the boiler, through the cylinder, to the condenser, and not by the loss of substance undergone by the several parts of the machinery on which it acts. In like manner, the mechanical or intellectual work done by the food we eat is to be measured, not by the change of substance of the muscles or brain employed as the agents of that work, but simply by the changes in the blood that supplies these organs, that is to say, undergone by the food used in its passage through the various tissues of the body, before it is finally discharged in the form of water, carbonic acid, or urea.

The Divine Architect has so framed the animal machine, that moves and thinks, that the same blood which, by its chemical changes, produces movement and thought, also repairs the necessary waste of the muscles and brain, by means of which movement and thought are possible; just as if the steam that works an engine were able, without the aid of the engineer, to repair the wear and tear of its friction and waste spontaneously; but no greater mistake is possible in physiology than to suppose that the products of the changes in the blood by which mechanical or intellectual work is done are themselves merely the

result of the waste of the organs, whether muscles or brain, on the exercise of which that work depends.*

The ancients, who derived all their knowledge from observation, and not from experiment, were well aware of the double duty imposed upon food in early life—of producing both the secular and the periodic variations of the body, or, in other words, of promoting growth, and of developing work. Their practical knowledge is summed up by Hippocrates in the aphorism, "Old men bear want of food best; next those that are adults. Youths bear it least, more especially children, and of these the most lively are the least capable of enduring it."

The food consumed in twenty-four hours, including air and water, undergoes a series of changes of a chemical character before leaving the body, in the form of one or other of its excretions. Some of these changes develop force, and others expend force, but the algebraic sum of all the gains and losses of force represents the quantity available for work. This work must be expended as follows:

1. The work of growth, (*secular.*)
2. The work of maintaining heat, (*periodic.*)
3. Mechanical work, (*periodic.*)
4. Vital work, (*periodic.*)

During childhood and youth the work of growth is positive, for a certain proportion of the food used is employed in building up the tissues of the body instead of being expended in actual work; it is, in fact, "stored up" in the body, as *vis viva* is stored up by the fly-wheel of machinery, and constitutes a reservoir of force that may be called upon at an emergency requiring sudden expenditure of force, as in case of illness, or to supply the gradual wasting of old age. In adult life and in old age, the work of growth ceases completely, except so far as is necessary to repair, from day to day, the small wastes of the organs employed in work; so that nearly the whole of the food employed is expended on the periodic work of the body. Hence we can readily see the reason for the aphorism which asserts that food is more necessary for the young than for the old, and more required by those of a lively disposition, either of mind or body, than by others.

* The very skill with which provision is made for the repair of the waste of the organ used as the instrument of work may mislead the observer into supposing that the work itself may be measured by the waste of its instrument. Thus, it has been shown by Mr. A. Macalister, of Dublin, that the heart, which has imposed upon it the necessity of working day and night without ceasing, during life, is furnished with double the usual supply of blood through the coronary arteries, which are injected twice for every single beat of the heart. If, indeed, it were possible to assume that all muscles wasted equally for equal quantities of work, and also to measure separately the products of that waste, we might then assume the waste of the organ as the measure of its work. Neither of these assumptions, however, can be admitted, for it can be shown that different muscles act under different conditions more or less advantageously, so that equal wastes would represent unequal works; and, also, it is impossible to separate in practice the products of waste of muscles from those of the general changes of the blood.

HIPPOCRATIC DOCTRINE OF INNATE HEAT.

Hippocrates was well aware of the connection between food and animal heat, although he erroneously regarded the animal heat as an innate property of the body that caused an appetite for food, instead of being itself produced by food; if we transpose his cause and effect, *mutatis mutandis*, all his maxims as to animal heat are true. Thus, he says:

"Growing animals possess most innate heat, hence they require most food; . . . . . but the old have least heat, and therefore require the least fuel."

"The cavities of the body are naturally warmest in winter and spring; . . . . . in these seasons therefore most food must be given; and since there is more innate heat, more nourishment is required; as may be seen in youths and athletes."

These maxims, when translated into modern language, express the well-known fact that the chemical changes of food that take place in the body produce animal heat, and that the necessity for food to supply mechanical work is greatest with the young and active, while the necessity for the production of animal heat is greatest in the cold seasons of the year. The direct connection of food with mechanical work is expressed in the following maxims:

"There should be no labor when there is hunger;" and its converse, "Let labor precede meals."

On principles such as those just given, the training of the athletes was conducted; and they were compelled to undergo a regular course, commencing with blood-letting and active purgation, and consisting of systematic muscular exercise suited to the nature of the contest intended, accompanied by a dietary, of which the chief ingredients consisted of biscuits and pigs' kidneys, washed down by a minimum of water. It is truly not much to be wondered at that those who survived the training were formidable in the boxing-ring or race-course.

The relation of animal heat to respiration is referred to by Hippocrates in a remarkable maxim:

"Those persons have the loudest voices who have most [innate] heat, for they inspire the largest quantities of the cold air; and the product of two great quantities must be itself great."

Galen believed the heart to be the center of "innate heat," but he was well aware that increase or diminution of respiration caused increase or diminution of heat, and was intimately connected with it. Thus he says:

"Since, therefore, the heart is, as it were, the hearth and fountain of the innate heat with which the animal is pervaded," &c.

"The necessity for respiration is the greatest and most imperious guard of the innate heat."

"Those persons in whom the innate heat has been much cooled breathe but little and slowly."

LAVOISIER'S THEORY OF ANIMAL HEAT.

The doctrine of "innate" heat, taught by Hippocrates and Galen, ruled in medicine for fifteen hundred years after Galen's death, until it received its death-blow from the genius of Lavoisier, who demonstrated in his celebrated memoir read before the French Academy of Sciences in 1783, that the source of animal heat is to be found in the combustion of the carbon of the body by the oxygen of the air received into the lungs by respiration. Lavoisier's experiments were repeated and confirmed in 1822 by Dulong and Despretz, and have formed the starting-point for all modern investigations on the relation of food to work. As already stated, the work done by food in the body may be divided into—

1. The work of growth.
2. The work of animal heat.
3. Mechanical work.
4. Vital work.

Lavoisier arranged his experiments so as to exclude almost all the foregoing kinds of work except that of animal heat. A Guinea pig was placed under a bell-glass inverted over a surface of mercury, and a current of fresh air was allowed to circulate through the apparatus, being passed at its final exit through tubes containing caustic potash, which arrested the carbonic acid produced by the animal. In this manner it was easy to ascertain the carbonic acid excreted by the increase in weight of the tubes of caustic potash during the experiment.

Lavoisier found that his Guinea pig, in ten hours, burned, on the average, 3.333 grams of carbon; and this quantity of carbon he estimated, from other experiments, as capable of melting 326.75 grams of ice at the freezing temperature. The same Guinea pig was then placed in an ice-calorimeter, and left in it for ten hours, during which time the heat of its body was found to have melted 402.27 grams of ice at the freezing temperature.

If we use, instead of the coefficient of combustion of carbon employed by Lavoisier, that now generally adopted from the experiments of Favre and Silbermann, the quantity of melted ice represented by $3\frac{1}{3}$ grams of carbon would become 364.78 grams instead of 326.75 grams. We are, therefore, entitled to say that the heat of combustion of expired carbon determined by Lavoisier is equal to

$$\frac{36478}{402.27} = 90.68 \text{ per cent.}$$

of the animal heat developed, which is regarded as 100 parts.

Two years later, in 1785, Lavoisier laid before the Royal Society of Medicine of Paris, an account of further experiments, also conducted on the breathing of Guinea pigs, by which he showed that of 100 parts of oxygen absorbed by those animals, 81 only reappeared in the form of carbonic acid, and 19 parts disappeared altogether. Lavoisier considered that these 19 parts of oxygen were employed in the body in the combustion of hydrogen, the product of such combustion being water.

If we use Lavoisier's data just given, and the known atomic weights of carbon, oxygen, and hydrogen, we shall have, for 81 parts of oxygen in the form of carbonic acid, and 19 parts of oxygen in the form of water, the following quantities of carbon and hydrogen consumed by the respiration of his Guinea pig in the same time:

$$\text{Carbon} = \frac{6 \times 81}{16}; \text{ hydrogen} = \frac{19}{8}$$

Multiplying these numbers by the heat-coefficients of Favre and Silbermann, we find—

$$\text{Heat produced by carbon} = \frac{6 \times 81}{16} \times 8080$$

$$\text{Heat produced by hydrogen} = \frac{19}{8} \times 34462$$

It has been already shown that the heat developed by the combustion of carbon in Lavoisier's experiment amounted to 90.68 per cent. of the heat emitted by the animal; hence the heat produced by the combustion of the hydrogen will amount to—

$$90.68 \times \frac{19 \times 34462}{8} \times \frac{16}{6 \times 81 \times 8080} = 30.24$$

By adding together the heats due to the carbon and hydrogen, we find that Lavoisier's experiments, when fairly interpreted by the data of modern science, give the following results:

Heat produced by the combustion of carbon and hydrogen....	120.92
Animal heat.....	100.00

Finally, in 1789, Lavoisier published further experiments, by which he showed conclusively that the consumption of oxygen by the body is notably increased by three causes—

1. By a lowering of the external temperature.
2. By the act of digestion.
3. By muscular exercise.

The experiments of Lavoisier were repeated in 1822 by Dulong and Despretz, and their results, when corrected, like those of Lavoisier, by using the modern heat-coefficients of carbon and hydrogen, are as follows:

The mean of Dulong's experiments on sixteen animals and birds is 90.6 per cent. of the animal heat given out; the lowest number, 85.5, belonging to a kitten sixty days old; and the highest number, 99.4, belonging to a puppy fifty days old.

M. Despretz obtained an average of 92.3 from sixteen mammals and birds; his highest number being 101.8, derived from an old female rabbit; and his lowest number being 84.2, derived from four owls.

The foregoing experiments left no doubt remaining in the minds of men of science as to the substantial truth of Lavoisier's doctrine of animal heat; and led immediately to a number of supplementary experiments, among the most remarkable of which were those of Regnault and Reiset.

Regnault directed his attention especially to the distribution of the oxygen absorbed by animals, between the carbon and hydrogen of their blood or tissues, which had been laid down by Lavoisier in the proportion of 81 to 19. He found that the proportion was not a fixed one, but varied with the food in a very instructive manner.

The average of his experiments on fourteen animals, including worms, lizards, and insects, as well as birds and mammals, was—

Oxygen combined with carbon	81.7
Oxygen combined with hydrogen	19.3

a result nearly identical with that found by Lavoisier. The highest proportion of oxygen combined with hydrogen occurred in the case of chickens fed on meat, and amounted to 32 per cent.; and the lowest proportion occurred in the case of rabbits fed on bread and oats, and amounted to 1 per cent. only.

Still more recent experiments, made with improved apparatus and methods by Pettenkofer and Voit, in Munich, show, like those of Regnault, that the proportion of the oxygen employed in forming carbonic acid to the whole oxygen absorbed varies with the food, ranging in the case of a large dog from 52.4 to 148.2, according as the animal was kept altogether without food, or fed upon a mixed diet of meat and sugar. These investigations have also shown that, under ordinary conditions, it is probable that a dog consumes nearly all the oxygen absorbed in the formation of carbonic acid.

Before leaving the subject of animal heat, it is worth while to estimate its amount in a manner that will bring it into comparison with ordinary mechanical work.

In Lavoisier's experiment with the Guinea pig, 402.27 grams of ice were melted in ten hours; from this fact we find, assuming the latent heat of ice at 142° F., and 772 as Joule's coefficient for converting British heat-units into foot-pounds,

Mechanical work-equivalent to the daily animal heat of Lavoisier's Guinea pig =

$$\frac{402.27 \times 24 \times 142 \times 15.432 \times 772}{7000 \times 10} = 233310 \text{ foot-pounds.}$$

As the average weight of a Guinea pig is four pounds, the preceding amount of work, representing animal heat, would be sufficient to raise the weight of the animal through a vertical height of—

$$\frac{233310}{4 \times 5280} = 11.05 \text{ miles.}$$

Ranke has shown, by experiments made upon himself, under various conditions of food and fasting, by means of Pettenkofer and Voit's apparatus, that his daily excretion of carbonic acid varied from 660 grams to 860 grams, showing a mean of 760 grams. His weight was 67 kilograms, from which fact, and the assumption that an English mile is 1,600 meters, we obtain, employing the constants already given, the height through

which the combustion of 760 grams of carbonic acid would raise the weight of 67 kilograms in 24 hours—

$$= \frac{760 \times 6 \times 8.080 \times 423}{22 \times 67 \times 1600} = 6.609 \text{ miles.}$$

The extreme values of the carbonic acid excreted, viz, 660 grams and 860 grams, would correspond to the heights of 5.74 miles and 7.48 miles, respectively.

Dr. Edward Smith has estimated the daily excretion of carbon from the lungs, in the case of four persons, as follows:

	Body weight.	Carbon.
Mr. Moul	173 pounds.	6.735 ounces.
Dr. E. Smith	196 pounds.	7.85 ounces.
Prof. Frankland	136 pounds.	5.60 ounces.
Dr. Murie	133 pounds.	6.54 ounces.

In order to convert the preceding data into vertical miles through which the body weignt is lifted, we must multiply the ounces of carbon by the following coefficient, and divide the product by the body weight:

$$\text{Coeff.} = \frac{8080 \times 9 \times 772}{16 \times 5 \times 5280} = 132.91$$

$$\log (\text{coeff.}) = 2.1235473$$

We thus obtain, for the heights through which the carbon consumed would lift the observers—

Mr. Moul	5.17 miles.
Dr. E. Smith	5.32 miles.
Prof. Frankland	5.47 miles.
Dr. Murie	6.53 miles.

Pettenkofer and Voit succeeded in producing a range of carbonic acid excreted by a large dog, weighing 33.3 kilograms, from 289.4 grams to 840.4 grams; the minimum corresponding to the 10th day of fasting from solid food, and the maximum corresponding to a diet of 1,800 grams of meat, 350 grams of fat, and 1,410 grams of water.

It may be easily shown, by a calculation similar to the foregoing, that these excretions of carbonic acid correspond to the mechanical works of lifting the weight of the dog through vertical heights of 5.03 miles and 14.62 miles, respectively.

Combining together the preceding results, and expressing them all in the natural units of the weights of the animals lifted through a height, we find—

Work due to animal heat.

MAN.

1. Dr. Ranke, (fasting)	5.74 miles.
2. Dr. Ranke, (well fed)	7.48 miles.
3. Mr. Moul	5.17 miles.

4. Dr. E. Smith	5. 32 miles.
5. Prof. Frankland	5. 47 miles.
6. Dr. Murie	6. 53 miles.
Mean	5. 952 miles.

This result agrees very closely with the calculation already made from 760 grams of carbonic acid, in the case of Dr. Ranke, viz, 6.609 miles.

Work due to animal heat.

ANIMALS.

1. Guinea pig	11. 05 miles.
2. Dog, (fasting)	5. 03 miles.
3. Dog, (overfed)	14. 62 miles.
Mean	10. 233 miles.

SOURCE OF MUSCULAR WORK.

As soon as it was satisfactorily established by Lavoisier and his successors that the natural combustion of carbon and hydrogen in the blood was sufficient, or somewhat more than sufficient, to account for the animal heat, it became a matter of great interest to physiologists to ascertain, if possible, how much of the work developed in the blood by chemical changes is employed in producing animal heat, how much in mechanical work, external and internal, and how much in vital or mental operations.

At the outset of this inquiry, it received a misdirection from the conjecture thrown out by Liebig, that the excretion of nitrogen (in the form of urea) gave necessarily the measure of the wear and tear of the muscular tissues themselves, which are composed of proteinic or nitrogenous compounds. This conjecture led to Liebig's celebrated classification of food into heat-producing and flesh-forming foods, which has been unhesitatingly received until lately, in this country, by physiologists and physicians. Before investigating the truth or falsehood of Liebig's theory, it is worth while to state the most recent results obtained as to the muscular work per day of which man is capable.

From numerous observations, of which some were made by myself, on the daily labor of hodmen, paviors, navvies, and pedlars, I have obtained the following mean:

Daily labor of man = 353.75 foot-tons = 109549 kilometers.

This quantity of work is the exact equivalent of the work done by a man of 150 pounds weight in climbing through one mile of vertical height, and is, as I have already shown, about one-sixth part of the work expended in producing and maintaining animal heat.

I was led to believe, from investigations made to determine the quan-

tity of urea excreted in various diseases, that a certain minimum quantity, equivalent to 2 grains per pound of body weight, was excreted quite independently of muscular exertion, and I proved that death was preceded in many chronic diseases by a fall in the urea excreted to 2 grains per pound. These investigations were made chiefly on patients dying of advanced kidney disease, in which the excretion of albumen had nearly or altogether ceased, and of patients dying of phthisis.

Pettenkofer and Voit found that the excretion of urea in a dog reduced from 33.3 kilograms to 29 kilograms by 10 days' fast, became 8.6 grams. And, since—

29 kilograms = 63.8 pounds.
8.6 grams = 132.7 grains.
Excretion of urea = 2.08 grains per pound of body weight.

Ranke obtained a precisely similar result from observations made upon himself, after long fasting, continued for several days.

If these views be well founded, it is plain that part only of the urea excreted can be regarded as due to muscular exertion, for 2 grains per pound (or 300 grains for a man weighing 150 pounds) must be set aside as a constant due to vital work, independent of muscular work altogether. Hence it would follow, supposing the muscular exertion to be measured by the increased excretion of urea produced by it, that the urea will not increase as fast as the muscular exertion, but it ought to increase regularly, although at a slower rate. With a view to settle this important question, I devised the following observations upon myself in the month of July, 1866, which prove conclusively that an increase of muscular exertion, amounting to fourfold, is not accompanied by any corresponding increase in the excretion of nitrogen in the form of urea.

I had previously ascertained by repeated experiments, extending from 1860 to 1865, that my excretion of urea (under ordinary conditions as to exercise, which never amounted to five miles per day) ranged from—

465. 09 grains per day, to
537. 47 grains per day.

501. 28 mean.

This quantity of urea I regarded as my natural physiological average, and it was so well established that I thought I should obtain an important result by comparing it with the average found from several days of unusual muscular exertion. I accordingly walked for five consecutive days in the hilly districts of Wicklow, noting carefully the horizontal distance traveled each day, and the vertical height traversed up and down. The vertical heights were reduced to horizontal distances, on the assumptions (which are well founded) that 20 is the proper coefficient for converting one into the other, and that the work of descent is half the work of ascent.

During the five days of observation the work done, expressed in horizontal miles of walking, was as follows:

First day.

	Miles.
Miles walked	11.4
Height ascended.....1,800 feet =	10.2
	21.6

Second day.

Miles walked	12.0
Height ascended.....2,400 feet =	13.7
	25.7

Third day.

Miles walked	11.6
Height ascended.....1,400 feet =	8.0
	19.6

Fourth day.

Miles walked	9.3
Height ascended.....1,400 feet =	8.0
	17.3

Fifth day.

Miles walked	10.4
Height ascended.....1,600 feet =	9.1
	19.5

From the preceding statement it follows that the average work d each day was 20.74 miles of horizontal walking, the result of which u the urea excreted was to be compared with the result already mentio as a physiological constant, determined under circumstances in wh the daily muscular work never exceeded five miles of horizontal walki

In order to determine the urea, I collected each day all the urine pass and kept one-fifth part of it; and at the close of the fifth day exami the mixture formed from the five days' urine. It was found to cont 501.16 grains of urea per day—a result practically identical with physiological quantity previously found by me under totally differ conditions, viz, 501.28 grains. I was much surprised at this result, I had previously believed in the theory laid down by Liebig, which tributed the excretion of urea to the disintegration of muscular tiss

It might be objected to the preceding reasoning that the combust of proteinic compounds represented by 501.28 grains of urea excrete

ıally sufficient to produce the mechanical force necessary to maintain muscular exertion of walking 20 or 21 miles per day.

. The urea excreted bears to the proteine consumed the proportion 4 to 79, as appears from their chemical compositions, viz:

Urea	$C_2 H_4 N_2 O_2$	60
Proteine	$C_{36} H_{27} N_4 O_{12}$	395

. In 100 parts of proteine there are 53.7 parts of carbon, and 7 parts ydrogen; the total heat due to the combustion of 1 gram of pro- e is, therefore,

	Heat-units.
0.537 gram of carbon	4.3389
0.070 gram of hydrogen	2.4123
	6.7512

his number, 6.7512, represents the maximum quantity of heat-units* ; could be produced by the combustion of 1 gram of proteine; but term depending on hydrogen in it should be reduced to five-ninths ts amount, in consequence of the hydrogen already combined with gen in the proteine. Hence we find—

Combustion of one gram of proteine.

	Heat-units.
Carbon	4.3389
Hydrogen	1.3402
	5.6791

. In 100 parts of urea there are 20 parts of carbon, and $6\frac{2}{3}$ parts of lrogen; the total heat, therefore, due to the combustion of 1 gram .rea is:

	Heat-units.
0.20 gram of carbon	1.6160
0.067 gram of hydrogen	2.3089
	3.9249

he term depending on hydrogen, in this result, should be reduced ne-half, in consequence of the hydrogen already combined with oxygen he urea.

[ence we find—

Combustion of one gram of urea.

	Heat-units.
Carbon	1.6160
Hydrogen	1.1544
	2.7704

*Heat-unit = 1 kilogram of water raised 1° C.

4. From the three preceding statements it is easy to see that, for every gram of proteine consumed, 0.8416 heat units are contained in the urea excreted; so that—

The digestion of 1 *gram of proteine gives out* 4.8375 *heat-units.*

It is easy to see that 501.28 grains of urea excreted correspond to 1,650 grains of proteine in the food, or to 106.92 grams; and the total work due to the digestion of this quantity of food may be found by multiplying it by the "*digestion coefficient*" already found, and by 423, which is Joule's coefficient for converting heat-units into kilogram-meters. Hence we have—

Work due to production of 501.28 *grains of urea*

$= 106.92 \times 4.8375 \times 423 = 218786$ kilogram-meters $= 704$ foot-tons.

This amount of theoretical work produced by nitrogenous food is double the work actually done during the walking excursion.

The average work was 20.74 miles horizontal per day, which may be considered as the exact equivalent of lifting my weight (knapsack and clothes included = 150 pounds), through one mile of vertical height. Hence the work actually done by me was—

$$\frac{150 \times 5280}{2240} = 354 \text{ foot-tons.}$$

This amount of muscular work accounted for almost exactly half the whole theoretical work supplied by the food that goes to form urea, viz, 704 foot-tons. But it has been already shown that 2 grains of urea per pound of body weight is required to maintain the vital work, including circulation and respiration; this would give (since I weighed 128 pounds) 256 grains of urea required for vital work, or almost exactly half of the 501.16 grains excreted, so that one-half of the available work might be considered as expended on vital work, and the other half as expended on external muscular work. This supposition, however, requires us to believe that the muscles act without loss by friction. This is not admissible, for I have elsewhere endeavored to show that there is a loss in the force applied by the muscles of various animals, in consequence of the friction of their tendons, amounting on the average, in man, to 35 per cent., and in the mastiff, to 41 per cent.

Hence it may be regarded as certain that the available force represented by 501 grains of urea is not sufficient to account fully both for vital work and for the external mechanical work expended by me during the experiments just described.

The foregoing observations and calculations were made in the month of July, 1866, but I did not then publish them, as I found afterward that I had been anticipated by Dr. Fick and Dr. Wislicenus, of Zurich, in a paper published in June in the Philosophical Magazine, on the urea excreted during an ascent of the Faulhorn. Professor Frankland, in a paper published in the same journal in September, 1866, corrected some erroneous reasoning that found its way into Fick and Wislicenus's paper, and further supplied, from direct experiment, the *digestion coeffi-*

cient of proteine, which had been obtained by me from calculation. The actual value of this important constant was found by him to be—

Actual value of digestion coefficient of proteine ..	4.3155
Calculated value	4.8375

My only object in now publishing an account of the independent experiment and calculation made by myself, is to confirm the certainty of the important fact first proved experimentally by Fick and Wislicenus, that the force due to the urea excreted in a given time is not sufficient to provide the actual work that may be done by the muscles in the same time.

Liebig and his followers, misled by a preconception of the simplicity of nature, assigned to nitrogenous food the duty of providing the force necessary for the production of muscular work, by supplying the waste of muscular tissue; while they supposed the farinaceous and fatty foods to provide the amount of animal heat required by the body.

The opponents of Liebig have fallen into the opposite error, and deny that nitrogenous food contributes any portion of the force employed in muscular work.

The truth, as is usual, lies between the two extreme hypotheses, and we are now compelled to admit that a given development of force, expressed in animal heat, muscular work, and mental exertion, may be the effect of several, perhaps many, supposable supplies of digested food, farinaceous, saccharine, fatty, and albuminous.

Just as a given algebraical function may be equated to a given constant, by the use of a certain definite number of values of its variable quantity, so may a given effect of work in the animal body be produced by certain definite though very different combinations of various kinds of food, the digestion of which follows each its own law, and develops its own amount of force. The number of roots in our equation of life increases the difficulty of solving it, but by no means permits the acceptance of the lazy assumption that it is altogether insoluble, or reduces a sagacious guess to the level of the prophecy of a quack.

Lavoisier supposed in his earlier investigations that animal heat was developed by the combustion of carbon and hydrogen in the lungs; just as in earlier times it was supposed to be produced spontaneously in the heart, which was imagined to be so hot as even to burn the hand that should imprudently venture to touch it.

In like manner, Liebig and his followers supposed the muscular work to be developed in the substance itself of the muscles that were its instruments.

Both of these doctrines are now justly repudiated by physiologists, and the view proposed in 1845, by Dr. Mayer, of Heilbronn, and recently developed with much ability by Mr. C. W. Heaton, of Charing Cross Hospital, in the Philosophical Magazine for May, 1867, that the blood itself is the seat of all the chemical changes that develop force in the

body, has gained favor among physiological chemists, and also met with acceptance among practical clinical observers.

Thus the human mind revolves in cycles, and the physicians of the nineteenth century are preparing to sit at the feet of Moses, and learn that the blood of an animal really constitutes its life; while South African theologians are disposed to reject his authority, because he happened to confound a rodent with a ruminant.*

Whatever be the kind of food employed, its effect in the production of force must be ultimately measured by the quantities of carbonic acid and water produced by its combustion, and there is no more convenient measure of the production both of carbonic acid and water than urea, so far as it goes. I shall prove shortly that every four grains of urea excreted represent five tons lifted through one foot; and I have shown by the preceding investigation that the work represented by urea is not sufficient to account for vital and external work, much less for animal heat. The investigations of Dr. Edward Smith, on the excretion of carbonic acid, enable us to show that the carbonic acid alone is sufficient to account for both vital and external work, and also for the production of animal heat. This may be proved as follows:

Dr. Smith has given results, from which may be deduced the quantities of carbonic acid excreted per minute during the four following conditions:

1. Lying in the horizontal position, and nearly asleep.
2. Fasting, and in sitting posture.
3. Walking at two miles per hour.
4. Walking at three miles per hour.
5. Working on the tread-mill, ascending at the rate of 28.65 feet per minute.

	Carbonic acid per min.
1. Sleep and rest	5.522 grains.
2. Sitting	7.440 grains.
3. Walking at two miles per hour	18.100 grains.
4. Walking at three miles per hour	25.830 grains.
5. Tread-mill	44.973 grains.

The foregoing quantities of carbonic acid per minute may be converted into vertical miles per hour for the body weight, by multiplying them by the following coefficient:†

$$\frac{60 \times 6 \times 8080 \times 9 \times 772}{22 \times 196 \times 5280 \times 5 \times 7000} = 0.025263$$

$$\log = \bar{2}.40420$$

*No reasonable person can fail to perceive the ignorance of the great lawgiver who will apply to him the test first proposed by Swift for Homer; Moses, like the author of the Iliad, was profoundly unacquainted with the discipline and doctrines of the Church of England.

† Dr. Edward Smith's weight was 196 pounds.

Performing this calculation we find—

	Carbonic Acid.	Body weight lifted through miles.
1	5.522 grains.	0.1400 mile.
2	7.440 grains.	0.1887 mile.
3	18.100 grains.	0.4591 mile.
4	25.830 grains.	0.6551 mile.
5	44.973 grains.	1.1406 mile.

It is easy to calculate that the external work done in the cases 3, 4, 5, was as follows:

	External work.
No. 3. Walking two miles per hour	0.1000 mile.
No. 4. Walking three miles per hour	0.1500 mile.
No. 5. Tread-mill	0.3256 mile.

Subtracting these amounts of work from the applied work, due to the production of carbonic acid, we find, as the quantities left for vital work, including circulation and respiration, and for the production of animal heat, per hour:

	Vital work and animal heat.
No. 3	0.3591 mile.
No. 4	0.5051 mile.
No. 5	0.8150 mile.

As I have already shown the work due to animal heat per day to be 6 miles, it follows that the work of animal heat per hour is 0.2500 mile.

Deducting this amount from the foregoing, we find for the vital work done, under the three different conditions—

	Vital work.
No. 3. Walking at two miles per hour	0.1091 mile.
No. 4. Walking at three miles per hour	0.2551 mile.
No. 5. Tread-mill work	0.5650 mile.

This result proves, in a striking manner, the great disadvantage under which an increased amount of muscular work is done in a given time; and it is quite in accordance with other results obtained by me from totally different experiments.

No two classes of animals can well differ more from each other than the cats and ruminants, one of which is intended by nature to eat the other. They differ in all respects as to food, the cats requiring a supply of fresh meat and blood for their health, and the ruminants being exclusively vegetable-feeders; yet in both classes we find a great development of muscular power, and of rapid action of muscles, qualities alike necessary to the pursuer and to the pursued. There can be no doubt that muscular work is developed in the cats from the combustion of flesh, and in the ruminants, mainly, if not exclusively, from farinaceous food. It is, however, worthy of remark, that the muscular qualities developed by the two kinds of food differ considerably from each other. The hunted deer

will outrun the leopard in a fair and open chase, because the work supplied to its muscles by the vegetable food is capable of being given out continuously for a long period of time; but in a sudden rush at a near distance, the leopard will infallibly overtake the deer, because its flesh-food stores up in the blood a reserve of force capable of being given out instantaneously in the form of exceedingly rapid muscular action.

In conformity with this principle, we find among ourselves an instinctive preference given to farinaceous and fatty foods, or to nitrogenous foods, according as our occupations require a steady, long-continued, slow labor, or the exercise of sudden bursts of muscular labor continued for short periods. Thus chamois-hunters setting out for several day's chase provide themselves with bacon fat and sugar; the Lancashire laborers use flour and fat, in the form of apple-dumplings; while the red Indian of North America almost transforms himself into a carnivore by the exclusive use of flesh-food; he sleeps as long and can fast as long as the puma and jaguar, and possesses stored up in his blood a reserve of force which enables him, like a cat, to hold his muscles for hours in a rigid posture, or to spring upon his prey, like a leopard leaping from a tree upon the back of an antelope.

If the preceding view of the muscular qualities developed by the two kinds of food be correct, important inferences suggest themselves as to the food that should be employed in relation to several kinds of work. Of these inferences I shall select two examples:

1. The nurses of one of our Dublin hospitals were formerly fed chiefly upon flesh-food and beer, a diet that seemed well suited to their work in ordinary times, which was occasionally severe, but relieved by frequent intervals of complete rest. Upon the occasion of an epidemic of cholera, when the hospital duties of the nurses became more constant, although on the whole not more laborious, they voluntarily asked for bacon fat and milk, as a change of diet from the flesh-meat and beer; this change was effected on two days in each week with the best results as to the health of the nurses, and as to their power of discharging the new kind of labor imposed upon them.

2. I have been informed, on competent authority, that the health of the Cornish miners break down ultimately from failure of the action of the heart and its consequences, and not from the affection of the lungs called "miners' phthisis." The labor of the miner is peculiar, and his food appears to me badly suited to meet its requirements. At the close of a hard day's toil, the weary miner has to climb by vertical ladders through a height of 100 to 200 fathoms before he can reach his cottage, where he naturally looks for his food and sleep. This climbing of the ladders is performed hastily, almost as a gymnastic feat, and throws a heavy strain (amounting from one-eighth to one-quarter of the whole day's work) upon the muscles of the tired miner, during the half hour or hour that concludes his daily toil. A flesh-fed man (as a Red Indian) would run up the ladders like a cat, using the stores of force already in reserve

in his blood; but the Cornish miner, who is fed chiefly upon dough and fat, finds himself greatly distressed by the climbing of the ladders—more so indeed than by the slower labor of quarrying in the mine. His heart, overstimulated by the rapid exertion of muscular work, beats more and more quickly in its efforts to oxidate the blood in the lungs, and so supply the force required. Local congestion of the lung itself frequently follows, and lays the foundation for the affection so graphically, though sadly, described by the miner at forty years of age, who tells you that "his other works are very good, but that he is beginning to leak in the valves."

Were I a Cornish miner, and able to afford the luxury, I should train myself for the "ladder feat" by dining on half a pound of rare beefsteak and a glass of ale from one to two hours before commencing the ascent.

The excretion of nitrogen by the cats and ruminants is very different, as might be expected from their food. I have ascertained that the urea discharged by a Bengal tiger and a sheep daily is as follows:

Bengal tiger	4,375 grains of urea.
Sheep	256 grains of urea.

It is worthy of remark, and serves to throw light on the meaning of the excretion of nitrogen from the body, that causes but slightly connected with muscular exertion in ruminants increase amazingly the excretion of urea. Thus I have found the following excretion of urea from a ram during the rutting season:

Ram, (rutting season)	1,493 grains of urea.

This amounts to a *sixfold* increase of urea, which cannot possibly be accounted for by the food consumed at the time, but requires us to assume a certain storing up of force, represented by nitrogenous compounds, which has been going on for a considerable period previous to the rutting season. A similar and equally remarkable storing-up of phosphates and carbonates takes place, previous to the rutting season, in the ruminants that shed their horns, which, in the *Cervus megaceros*, often weigh 90 pounds.

These remarkable phenomena remind us of the maxim of the wise Hippocrates, who recommends moderation in the use of the gifts of the Golden Venus as well as in those of Ceres and Bacchus: "Πόνοι, σιτία, ποτά, ὕπνος, ἀφροδίσια μετρια," with which may be compared its converse in the Latin proverb: "*Sine Cerere et Baccho, friget Venus;*" or, as the old proverb says, "When the wolf comes in at the door, love flies out at the window."

APPLICATION OF THEORY TO DISEASED CONDITIONS OF BODY.

The relation of food to work, complicated enough in health, becomes more so in disease, and the problem to be solved by rational theory becomes still more difficult. I cannot attempt even to sketch an outline of this part of my subject considered in general, but shall content myself with asking your attention to three remarkable examples of disease which

illustrate the principles I have attempted to lay down. These diseases are—

A. Typhus fever.

B. Cholera asiatica.

C. Diabetes mellitus.

A. *Typhus fever.*—In typhus fever a prominent symptom is the remarkable elevation of temperature, accompanied by an increased excretion of urea and carbonic acid by the kidneys and lungs, indicating (as no food is taken) an increased morbid metamorphosis of the blood and tissues. The temperature commonly rises to 104° F., representing an increase of upward of 5° F. above the normal temperature.

If we knew the cause of this increase of temperature, or, rather, of the increased metamorphosis of which it is the sign, we should know the cause of *typhus* fever, and learn to combat the disease on rational grounds. At present the cause is unknown, and, therefore, the physician is forced to treat the symptoms as they appear, instead of attacking the cause of the disease. Let us examine for a moment the terrible significance of the symptoms.

Your patient lies for nine or ten days supine, fasting, subdelirious, the picture of weakness and helplessness, and yet this unhappy sufferer actually performs, day by day, an amount of work that might well be envied by the strongest laborer in our land.

The natural temperature of the interior of the body is 100° F., while the temperature of the corresponding parts in typhus fever is at least 105° F. This seems at first sight a small increase—only 5 per cent. of the whole—but it is in reality 2½ times as great as it appears, and actually amounts to 12½ per cent., or one-eighth part of the total animal heat; for the total quantity of heat given out by the heated body is proportional (from Newton's law of cooling) to the elevation of its temperature above the temperature of equilibrium, toward which it tends. If we suppose this equilibrium temperature to be 60° F., then the quantities of animal heat given out in typhus fever and in health will be in proportion of 45 to 40, showing that the animal heat of typhus exceeds that of health by one-eighth of its amount.

We have already seen that the work due to animal heat would lift the body through a vertical height of six miles per day; and it thus appears that an additional amount of work, equivalent to the body lifted through nearly one mile per day, is spent in maintaining its temperature at fever heat.

If you could place your fever patient at the bottom of a mine twice the depth of the deepest mine in the duchy of Cornwall, and compel the wretched sufferer to climb its ladders into open air, you would subject him to less torture, from muscular exertion, than that which he undergoes at the hand of nature, as he lies before you, helpless, tossing, and delirious, on his fever couch.

The treatment of this formidable disease in former times consisted of

purging, vomiting, and bleeding the patient, with the view of eliminating an imaginary poison, and so helping nature to terminate the disease.*

In modern times, thank God, the physician either does not interfere at all, or adopts the rational process of retarding the disintegration of the tissues consumed to supply the fever heat, by furnishing in their stead fuel, in the form of wine and beef-tea, sufficient to maintain the increase of temperature imperiously required.† This practice may be justly considered rational, because the condition of the circulation admits of its application; and it is considered good, because it has been rewarded with success in the hands of the skillful clinical physician. In concluding this sketch of the prominent symptom of typhus fever, and as an illustration of the eagerness with which every possible combustible in the body is made use of, I may mention, on the high authority of Dr. Stokes, of Dublin, that the very urea excreted by the kidneys is not permitted to leave the body without first paying its tax to fever, by being burned into carbonate of ammonia, thus rendering the urine of an advanced case of bad typhus fever eminently alkaline.

B. *Asiatic cholera.*—This remarkable disease presents, as every one knows, three distinct stages, viz:

1. The premonitory stage of diarrhœa.
2. The stage of collapse.
3. The stage of consecutive fever.

The stage of collapse exhibits the following symptoms: Vomiting or purging; muscular cramps; suppression of bile and urine; lowering of

* Νούσων φύσιες ἰητροί.—EPID. vi, Sect. v, 1.

† It is not intended by this to assert that a high temperature, 104° to 108° F., must be maintained in order that the disease may terminate favorably, for the very contrary is the fact. The blood, in typhus, as in other pyrexies, is a fluid possessed of greater oxidizing power than it has in health; in consequence of this, an increased metamorphosis of tissues takes place, accompanied, of course, by an elevation of temperature, which measures precisely the oxidizing power of the blood, and the risk to life in typhus is directly proportional to the rise in temperature. The indications of the sphygmograph are similar to those of the thermometer, a "*full dicrotic*" pulse corresponding to a temperature of 103° F., and the pulse of "*death agony*," with the heart's first sound gone, corresponding to a temperature of 109° F. There is no case on record of recovery from a condition marked by such a pulse and temperature.

The effects of alcohol, administered in fever, when the temperature does not exceed 105° F., are twofold—immediate and secondary. The immediate effect is to supply a hydrocarbon to the blood, which is decomposed by it in preference to the body tissues. The secondary effect of alcohol is to change the blood itself, which thus loses its oxidizing qualities; in consequence of which the temperature falls, the hyperdicrotic character of the pulse disappears, and the destructive metamorphosis of the tissues becomes lessened. The statement here given of the effects of alcohol given in typhus, to the exact amount required by the condition of the blood, in narcotic doses, is borne out by clinical observation, and is independent of any theory as to the cause of typhus.

It is not at all improbable that the theory of contagious disease, that each such disease owes its existence to a special living organism and not to an organic poison, may ultimately prove to be correct.

body temperature to 95° F.; extreme prostration of strength; extremities pulseless; and face hippocratic.

When death occurs during collapse, the following symptoms are usually found on careful examination of the corpse: The temperature rises to 103° F.; the muscles give out their characteristic susurrus CCC, and exhibit spontaneous movements; the whole train of symptoms producing the effect of a ghastly attempt at resurrection.*

In this disease we have phenomena respecting animal heat the very reverse of those found in typhus fever; the body performing one vertical mile short of its daily work, instead of one mile in excess. The prostration of strength resulting from this deficient combustion is so great that death is often caused by bringing the patient to hospital in a cab instead of upon a stretcher, by his walking up a dozen steps into his ward, and sometimes even fatal results have followed a sudden effort to sit up in bed to vomit.

The rise of temperature after death, and the continuance of muscular susurrus and motion, tend to prove that the impeded circulation, which is the prominent symptom in cholera collapse, is due to constriction (probably vasomotor-nervous) of the capillaries, in consequence of which the muscles are deprived of their supply of freshly oxidized blood, the result of which is necessarily contraction and cramp, which produces the excessive agony that characterizes this disease.

All authorities on cholera, whether their object be to "impede" or to "assist" nature, are agreed that medicines, whether astringent or purgative, are not only useless, but dangerous, in the stage of collapse.

It is useless to give alcoholic fuel to restore the loss of animal heat, for there is no circulation to cause the oxidation of the hydrocarbons.

It is equally useless and more dangerous to give opium, to check the remaining purging that exists; for if vomiting have ceased, your acetate of lead and opium pills lie as if in the stomach of a corpse, and at the termination of collapse, your patient enters upon the consecutive fever, with perhaps a dozen grains of opium in his stomach, placed there like an explosive shell by your ill-timed zeal, and rapidly passes into a comatose condition, from which he never for a moment rallies. His death is always accredited by the registrar to cholera morbus and not to opium.

Purgatives and emetics† in cholera collapse effect the same object as opium, but with greater rapidity. In the stage of blue collapse, the chances of life and death are almost exactly equal, and the slightest additional loss of force turns the wavering beam on the side of death. The effects of a brisk purgative or emetic (if they act) upon a patient, unable to climb a dozen steps, or sit up for a quarter of an hour, without

* It is startling, on making a post-mortem examination of a cholera patient alone and by candle-light, to witness, on the first free incision of the scalpel, the hand of the corpse rise slowly from its side and placed quietly across its breast.

† When mustard is used, its conservative effects as a stimulant sometimes counteract its destructive effects as an emetic.

fatal syncope, may be easily imagined; and the use of them cannot be justified by any arguments borrowed from right reason.

A remarkable though transient improvement takes place in cholera collapse by the injection of warm water (brought to the specific gravity of serum by the addition of mineral salts) into the veins or bowels; the patient loses the cramps, feels that he is about to recover, speaks to his friends, and often transacts whatever business is necessary; but speedily falls back into collapse. The improvement in his condition is altogether due to the temperature of the fluid injected, which supplies for a brief period the deficient animal heat, permits a partial oxidation of the blood, restores the capillary circulation in the muscles and so destroys their cramp, and, by supplying the deficient work required, removes for the moment the fatal prostration of strength. Any one who has witnessed the remarkable effects of warm liquids thus injected in cholera collapse must feel that recovery would be certain if the improvement could by any possibility be made permanent.

Our hopes for the future, as to the treatment of cholera, lie, as I believe, in the direction of supplying to the body directly its lost animal heat. I have witnessed the happiest results from an injection of warm salt water into the bowels, assisted by hand friction of the surface with turpentine and chloroform, and the application of bags of hot salt along the spine; in cases treated in this manner, we may expect to witness cessation of muscular cramp, restoration of perspiration to the skin, with increase of capillary circulation, and finally, to reward our efforts, a return of the excretions of urine and bile; when these reappear, all vomiting and purging cease, and our patient is almost cured.

After recovery, the contrast between the cholera and fever patient is as great as it was during sickness. The fever patient has been overworked for nine or fifteen days without a suitable supply of food, and when convalescent experiences a complete exhaustion of strength that lasts for many weeks. The cholera patient, on the other hand, has been prevented from working by constriction of the capillary vessels, caused by the absorption of the cholera poison,* and feels, on recovery, much like a man that has been half drowned, while the fever patient resembles a man that has been half starved; the one is able to return to his work in the course of a few days, the other only after the lapse of as many weeks.

There are two popular superstitions prevalent among medical men respecting nature, which yearly slaughter hecatombs of victims, viz, that nature is simple in her operations, and beneficent in her intentions; she is often both simple and beneficent, but at other times she is unquestionably both complex and malevolent.

An Egyptian fable informs us that the votaries of goddess Nature were divided in opinion as to whether she was transcendently beautiful

* Whatever this may be, its period of incubation is 49 hours; that of strychnine is 22 minutes.

or hideously ugly; and that, in order to keep up this difference of opinion which suits her purpose, she always wears a thick veil over her face.

"For, with a veil that wimpled everywhere,
Her head and face were hid, that mote to none appear;
That some do say was so by skill devised,
To hide the terror of her uncouth hue
From mortal eyes that should be sore agrised;
For that her face did like a lion show,
That eye of wight could not endure to view;
But others tell that it so beauteous was,
And round about such beams of splendor threw,
That it the sun a thousand times did pass,
Nor could be seen but like an image in a glass."

Before trusting nature in the matter of cholera, and proceeding to help her, it would be well to inquire whether she intends to cure the patient by her evacuations or to put him into his coffin. For myself, I greatly mistrust her, and would wish to ask, previous to assisting her, whether she is really my mother or only my stepmother. Our experience in Dublin has shown that no more effectual mode of shortening life could be devised in cholera than the "eliminant" treatment; and it was accordingly abandoned as soon as tried in that city.

It is much to be regretted that an authority so deservedly held in high repute as that of Sir Thomas Watson can be now quoted in favor of the treatment of cholera, by the maxim, *similia similibus curantur*. So far as Dr. Watson has informed us, his change of opinion rests upon the statements of others, and not upon his own experience. He has suddenly become an advocate of the castor oil, rhubarb, calomel, and eliminant treatment of cholera, and writes as follows:

"When I last spoke on this subject in these lectures, I stated that the few recoveries which I had witnessed had all taken place under large and repeated doses of calomel, but I could not venture to affirm that the calomel cured them. At present I am much disposed to believe that by its cleansing action the calomel may have helped the recovery; and after all that I have since seen, heard, read, and thought upon the matter, I must confess that in the event of my having again to deal with the disorder, I should feel bound to adopt, in its generality, the evacuant theory and practice."

Sir Thomas Watson omits to add that the cases here referred to were only six in number, of whom three died and three recovered, which is exactly what might have been expected if he had not interfered at all.

Cholera from Bengal visits these islands at intervals of about seventeen years, and it is much to be feared that on its next outbreak hundreds of patients will be sacrificed, in obedience to the dogma that asserts it to be our duty to assist nature.

C. *Diabetes mellitus*.—This disease furnishes us with one of our best proofs that all the chemical changes, by means of which work is produced, take place in the blood and not in the tissues of the body; and

at the same time, an examination of its phenomena explains satisfactorily the regimen and diet which has been found, by experience, most suitable to the diabetic patient. I shall illustrate the disease by a case which was placed under my control by Dr. Stokes some years ago.

A young man (æt. 20) named Murphy suffered from fever (enteric?) in November, 1859, and on recovering became diabetic; he was admitted into the Meath Hospital in October, 1860, where he remained under my observation until his death, on the 12th January, 1861.

He was allowed, for nine weeks, to eat as much as he liked of certain kinds of food, which were varied, week by week, to suit his wants, my object being to obtain, if possible, the natural constants of the disease, undisturbed by external interference; the only medicine used by Dr. Stokes's order being opium, to produce sleep, and a little creosote occasionally, to promote digestion. As the details of this experiment have been fully published, I shall confine myself to the final results. His food and excretions were analyzed from week to week, so as to determine the total quantities of sugar-forming and urea-producing food, as well as the sugar and urea actually excreted.

During six of the nine weeks, the sugar excreted was in excess of the sugar ingested; and the means of the whole nine weeks' daily excretion and ingestion of sugar were—

	Grains.
Sugar excreted	9,773
Sugar ingested	9,321
Difference	452

During two of the nine weeks of observation, the urea excreted was in excess of the urea ingested; and the means of the whole nine weeks' daily excretion and ingestion of urea were—

	Grains.
Urea excreted	1,182
Urea ingested	1,349

The foregoing facts illustrate strikingly one of the prominent symptoms of diabetes, viz, the canine appetite; the quantity both of sugar-producing and urea-forming food consumed is more than double what is necessary to maintain a vigorous laborer in perfect health. An examination of the excretions explains the other prominent symptom of diabetes, viz, the complete prostration of strength in the patient, notwithstanding the great amount of food consumed.

In a state of health, food produces three excretions only, viz, urea, carbonic acid, and water; in diabetes, the farinaceous foods appear in the excretions as sugar, and not as carbonic acid and water; and the work necessary to maintain animal heat must be provided altogether at the expense of flesh food, which is the very form of food least fitted to maintain it.

The diabetic patient resembles a racing steamboat on the Mississippi whose supply of coals is exhausted, and whose cargo furnishes nothing better than lean pork hams to throw into the furnace to maintain the race. It cannot be wondered at that our poor patient, under such disadvantageous conditions, fails to keep in the front.

Let us compare together the minimum of work necessary to keep Owen Murphy alive, with the work actually supplied to him by the food digested.

1. I have already stated that Dr. Ranke found 660 grams of carbonic acid excreted daily, in the extreme fasting condition, when he weighed 67 kilograms. Now, since—

660 grams = 10185.35 grains,
67 kilograms = 147.71 pounds,

we find 69 grains per pound of body weight as the minimum excretion of carbonic acid consistent with continued life.

This quantity of carbonic acid represents a work generated by its production that would lift its corresponding pound of body weight through a height of—

$$69 \times \frac{6}{22} \times 8080 \times \frac{9}{5} \times \frac{772}{7000 \times 5280} = 5.716 \text{ miles.}$$

Under ordinary conditions, the greater part of this carbonic acid and work is produced by the digestion of farinaceous food; but since, as we have seen, the farinaceous food is excreted as sugar in the diabetic patient, and, therefore, does no work at all, the whole of the foregoing work must be done by the digestion of other kinds of food.

I have already shown that it follows, from Lavoisier's experiments, (confirmed in a remarkable manner by those of Regnault,) that the work done by the combustion of carbon in the body is to the work done by the combustion of hydrogen in the proportion of 9068 to 3024, almost exactly 3 to 1; hence we have the work done by Owen Murphy, as a minimum in health—

	Miles.
Due to carbon	5.716
Due to hydrogen	1.905
	7.621

This result is somewhat in excess of the truth, for the same reason that the calculated *digestion coefficient* of proteine is in excess of that found by Frankland from experiment; for the combustion coefficients of carbon and hydrogen in organic compounds are slightly less than when free. If we are permitted to reduce 7.621 miles in the same proportion as in the digestion of proteine, viz, 48 to 43, we shall find—

Owen Murphy minimum of work consists of body weight lifted through 6.83 miles.

Let us now compare this minimum with the work actually performed

by him when suffering from diabetes, by the digestion of flesh food and production of urea.

2. I have already shown that the work produced by the formation of 501.28 grains of urea is 704 foot-tons by calculation from the composition of proteine and urea. This result should be reduced in the proportion of 48375 to 43155, in order to obtain the work given by Professor Frankland's experiments. Making this reduction, we find that 500 grains of urea correspond to 626.3 foot-tons of work, or 100 grains urea to 125.26 foot-tons; or, in other words, *every four grains of urea excreted correspond to five tons lifted through one foot.*

Owen Murphy excreted, on an average, 1,182 grains of urea daily during nine weeks, which, by the foregoing rule, are equal to—

$$1475 \text{ foot-tons} = \text{Murphy} \times x$$

where x represents in miles the height through which the patient could be lifted by the work done per day, and is equal to—

$$x = \frac{1475 \times 2240}{93.56 \times 5280} = 6.69 \text{ miles.}$$

This result is almost exactly equal to that already found as the minimum consistent with continued life, and explains in the most satisfactory manner the complete prostration of the patient, notwithstanding the consumption and digestion of more than double the usual quantity of flesh food.

In corroboration of the foregoing conclusion, I may mention that Murphy's temperature was found to be constantly 2° F. below that of other patients (chronic) placed in the same ward, and, in other respects, under similar conditions.

His unfavorable symptoms (so long as his powers of digestion were not impaired) were invariably alleviated by the free use of flesh food and fat, the latter being instinctively preferred by him; so much so, that during the delirium that preceded his death for twenty-four hours, he raved incessantly about "fat, roasted fat, which the angels of heaven were preparing for him."

I have studied many other cases of *diabetes mellitus*, and found similar results in all; but I feel it to be unnecessary to describe them, as one well-ascertained train of phenomena, carefully observed and recorded, is quite sufficient to establish the order of nature.

CONCLUSION.

I have, now, Mr. President and gentlemen, to apologize for the length of time during which I have spoken, and to thank you for the patience with which you have listened to me. I am well aware how much I am indebted to your kindness, for I labored under two serious disadvantages in addressing you—in the first place, I had undertaken a task beyond my strength; and again, my address is made shortly after you had, like myself, been charmed and instructed by the luminous, learned, and

eloquent oration of Professor Rolleston. I felt confident, however, that I possessed one advantage that he did not; I was a stranger in Oxford, and believed that my faults in matter and style would be leniently criticised; in this expectation, I am happy to say I am not disappointed: and again I thank you for your kindness. Two other advantages I share with him, which have contributed to his address as much as to my own—a profound respect and reverence for all honest laborers in search of truth, whether they have preceded us by twenty years or by two thousand years; and an unwavering confidence and faith in the future that lies before the science of medicine. We traverse a sea mapped with imperfect charts, but assured of a safe guide in our compass and stars; but we cannot afford to neglect a single rock or shoal, buoyed for us by the skill and care of those that have preceded us. Let us follow their example, and mark with conscientious care, for our successors, the dangers we ourselves discover and escape.

Assembled, as we are, within the halls of the University of Oxford, the center and heart of all that is intellectual and religious in the life of England—a university that borrows its accurate logic, as well as its refined ethics, from the lips of Aristotle; that reverences Euclid as the fountain and source of its elegant geometry; and sits at the feet of Homer, Pindar, and Eschylus, to learn its poetry—we need not fear that Hippocrates and Galen will ever want admirers and students; but the Oxford of to-day has taught us, what many did not anticipate, that she is equally ready and skillful, as she has proved herself to be in cultivating literature, to devote her vast intellectual energies to the encouragement and development of the natural sciences, based upon the solid and only permanent foundation of mathematical research. The efforts made within the last few years by Oxford to encourage within her walls the mathematical and natural sciences, have won for her the respect, and warmed toward her the hearts, of all that search for truth in the study of nature. Our brothers in Oxford, like the Athenians at Syracuse, have gone on board the fleet, while we watch them from the shore, sympathizing in the sea-fight; as they win, we shout; when they fail, we weep.

Long may the union of the far distant, but never to be forgotten, past, with the living present, that now exists in Oxford, continue. No science, no profession, can benefit so much by it as that of medicine.

HYDROGEN AS A GAS AND AS A METAL.

By Dr. J. Emerson Reynolds.

Notes of a lecture delivered in the theater of the Royal Dublin Society.

When the programme of this course of lectures was published, it became evident that the subject of the present one was, by a singular coincidence, closely connected with that of two of the earlier lectures of the series. I refer to the discourse of Mr. Stoney on "Meteoric Showers," and of Professor Ball on "Nebulæ." In the latter lecture, we learned that many of the thin mists observable in the heavens are not star clusters, as they were long supposed to be, but are enormous masses of gaseous matter in a state of intense ignition. The examination of the light emitted by these nebulæ enables us to state with certainty that at least one elementary body well known upon this earth is present in all of them as a principal constituent, and that element is one which chemists call hydrogen. In Mr. Stoney's lecture on "Meteoric Showers," he pointed out that some of these strange visitors to our globe, the meteoric stones, are found to contain pent up within them a certain gas, which gas has been shown by analysis to be hydrogen. We find, then, this hydrogen in enormous quantities throughout space, and at so great a distance from our planet that the human mind is unable to appreciate the interval which separates us from even the nearest of those mighty gaseous oceans. Again, we find this hydrogen carried to our planet by those strange wanderers of interstellar space, the meteors. And, finally, we have it on this earth, not in the free state, it is true, but as an essential constituent of one of the most important components of this globe, viz, water.

Our object in this lecture, then, is to study this remarkable element, hydrogen, as we meet with it here, to determine some of its chief properties, and to ascertain its nature.

It has been already said that our chief storehouse of hydrogen on this earth is water, but we find it in many other well-known bodies; for instance, in the dreaded "fire-damp" of our coal mines we have the hydrogen combined with another element, carbon. Again, common coal-gas contains a large proportion of hydrogen; and I have only to mention that this same body is an essential constituent of the bread we eat, the sugar we mix with our tea, the clothes we wear, of our flesh and blood too, in order to show that this is one of the most widely diffused of that class of bodies known to chemists as elementary forms of matter. But though we find hydrogen in all the substances mentioned just

now, and in many more besides, for the purpose of the present lecture we shall confine our attention to one of its most remarkable and widely diffused compounds, viz, water.

Water, in whatever condition we find it in nature, whether solid, liquid, or gaseous, (as steam,) is a compound body, being made up of two simple forms of matter—the one called oxygen, the principal constituent of the air we breathe, and the other hydrogen. Chemists are acquainted with several modes of breaking up the compound water into its two elementary components; but one of the most convenient methods we can employ for effecting this analysis of water is to make electricity tear asunder its two constituents. When water is made part of a galvanic circuit, by plunging the two poles of a galvanic battery into a vessel of the liquid, we find that bubbles of gas are evolved at each pole. By a very simple arrangement, we can collect the gases given off at each terminal of the battery, and we then find, on testing the products, that two colorless gases are obtained, possessing widely different properties. We observe that the gas liberated at the end of the wire connected with the platinum plate of the galvanic battery (the positive pole) is colorless, heavier than atmospheric air; and that when a glowing wooden match is dipped into a vessel filled with the gas, the wood burns with great brilliance, though the gas does not itself take fire. This peculiar gas is therefore a powerful supporter of combustion, though incombustible itself, and is called oxygen. We now turn our attention to the gas given off at the negative pole of the battery, *i. e.*, at that connected with the zinc plate. This is also found to be a colorless gas, but very much lighter than air, and incapable of supporting the combustion of a burning taper plunged into it; but though not a supporter of combustion in the ordinary sense of the term, it possesses the remarkable property of burning itself with a pale lambent blue flame. This is the gas hydrogen—the remarkable body whose chief properties we have now more especially to study.

[Other modes of liberating hydrogen from water were shown, and the leading properties of the gas demonstrated.]

When hydrogen burns in air, its sole product of combustion is water; hence the name of this remarkable substance, signifying "water-producer." But oxygen and hydrogen can also be made to combine and produce water when presented to each other *in conditione nascenti*, or at the moment of liberation from other forms of combination. The importance of knowing this fact will be apparent further on.

The beautiful researches of the late Professor Faraday have made us familiar with the fact that many of the gases known to chemists are merely the vapors of extremely volatile liquids; for, on subjecting these gases to very great pressure and to intense cold, in many cases liquids are obtained and even solids, which, on removal of the pressure under which they were produced, resume the gaseous condition at ordinary temperature. Hydrogen has been likewise subjected by the learned

Dr. Andrews, of Belfast, to enormous pressures, and to extremely low temperatures, but without exhibiting the slightest tendency to condensation. Hence it has generally been considered a permanent gas; but recent investigations, conducted by the master of the British Mint, the learned and distinguished Professor Graham, tend strongly to show that hydrogen gas, as we meet with it under ordinary circumstances, is really *the vapor of a highly volatile metal.*

It may be now generally stated that when a solution containing a metal and a non-metallic body is decomposed by a galvanic current, the metal is usually deposited on the negative pole, and the non-metallic body on the positive electrode. If, for instance, we take a solution of common blue vitriol, or sulphate of copper, and plunge the poles of a battery into the liquid, we find that immediately metallic *copper* is deposited on the wire forming the *negative* pole, while the sulphuric acid (a non-metallic body) appears at the positive end. If now we plunge the two poles into plain water, which, as we have already seen, is a compound of hydrogen and oxygen only, the hydrogen appears at the *negative* pole and the oxygen at the opposite one. We learn, then, in applying the galvanic test, that hydrogen arrays itself on the side of *metals*, and this fact is completely in accord with the view of its nature referred to above.

Again, it is a well-known fact that metals are capable of uniting with each other so as to form compounds called *alloys;* thus, brass is an alloy resulting from the fusion of the two metals copper and zinc in suitable proportions. But it is not always necessary that the two metals should be heated together in order to make them combine; for, if we take a slip of gold and plunge it into some of the liquid metal, mercury, or quicksilver, as it is called, the gold and mercury combine with each other to form an alloy or "amalgam," possessing a strong metallic luster. To go just one step further: if we convert this metal, mercury, into a colorless, invisible gas, which we can do by applying sufficient heat, and if into a vessel filled with this mercury gas we plunge a slip of gold, we find that the two metals combine or amalgamate nearly as easily as under ordinary circumstances. If, then, we can accomplish so much with the mercury gas, whose metallic nature is certain, why may we not make hydrogen gas alloy with some metal also?

By the very beautiful and interesting discovery that certain metals possess the power of absorbing enormous quantities of hydrogen without loss of metallic appearance, Professor Graham has greatly strengthened the evidence in favor of the metallic nature of hydrogen, and has even gone so far as to calculate the density of the metal, which he calls "hydrogenium."

Professor Graham found that certain metals—palladium and platinum more particularly—possess the extraordinary power of absorbing large volumes of hydrogen gas, and retaining it in some kind of combination. In order to demonstrate this, it is only necessary to take a plate of pal-

ladium foil, and, having connected it by a wire with the zinc end of a galvanic cell, to immerse the plate in acidulated water, the positive pole being connected with a plate of platinum likewise immersed in the liquid. hydrogen is immediately set free at the palladium surface, and oxygen at the platinum end. The latter gas is given off in bubbles from the platinum, whereas the hydrogen is absorbed by the palladium.

The palladium is capable of thus absorbing about *nine hundred times* its volume of hydrogen, and this enormous absorption or condensation of hydrogen within the pores of the metal takes place without any material alteration in the color of the palladium, *the latter retaining its metallic appearance.* This, among other circumstances, induced Professor Graham to regard the charged palladium as being a true *alloy* of palladium with the metal *hydrogenium;* for it has been found that when two metals unite, the compound resulting retains the characters of a metal, whereas this is not the case when a metal and a non-metallic body combine. In order to exhibit this absorption on a large scale, I have arranged the following experiments:

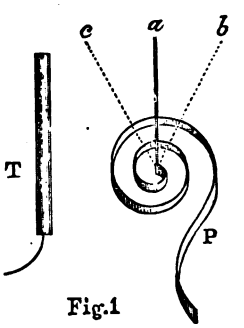

Fig.1

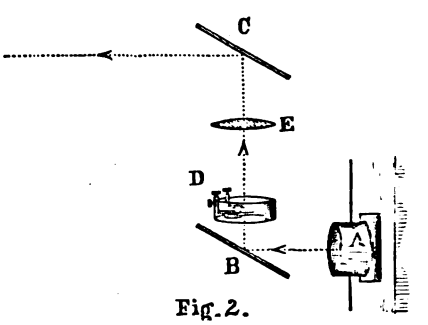

Fig.2.

A small glass cell is partially filled with water, slightly acidulated with sulphuric acid. Into this water a bar of metallic tin is dipped; this bar is of the size shown at T, Fig. 1, and is supported in a horizontal position by means of a varnished wire clamped to the side of the glass cell with the aid of a binding-screw. Having secured T in its position, we now take a slip of rather stout palladium foil, about four inches long, and a quarter of an inch wide, and coil it as shown at P; to the end within the spiral is now attached a fine fiber of glass by means of a minute quantity of cement, and this is so adjusted that the glass shall act as a needle-indicator, as shown in the diagram. The palladium is then attached to the edge of the glass cell by means of a binding-screw and varnished wire. When the cell, so arranged, is placed at D, Fig. 2,* the image is projected on the screen, as in Fig. 1.

* This projection may be most conveniently effected by means of the apparatus shown in section at Fig. 2, and which was arranged for me by Mr. Yeates, of Dublin. At A we have the front of a lantern with the object-glasses removed, the light oxyhydrogen, oxycalcium, or any other, having to pass only through the condensers. After passing the condensers, the rays fall on an ordinary mirror, B, suitably inclined to the beam of

Without disturbing the apparatus, we now connect, by means of the binding-screw and a copper wire, the palladium spiral with the zinc plate of a galvanic battery—one or two cells are sufficient—and the tin rod is connected with the opposite plate of the battery. Immediately on making contact, the water is decomposed by the electric current, hydrogen being liberated at the surface of the palladium, and oxygen on the tin. The latter gas is set free in bubbles, but the hydrogen, instead of being liberated in the gaseous form, is absorbed by the palladium; the volume of the metal is thereby increased, and the coil opens out as if endued with vitality. In doing this the glass needle is made to travel over several feet on the screen, and assumes the position represented by the dotted line *b*.

In this way we are able easily to show the expansion of the palladium then charged with hydrogen; but it is obvious that, on the removal of the hydrogen, the needle should return to its original position. In order to take away the hydrogen from the palladium, we have simply to reverse the poles of the battery; that is to say, we now connect the tin bar with the negative wire, and the palladium with the other pole. Now, on passing the current, oxygen is set free at the surface of the palladium spiral, and hydrogen on the tin. The oxygen, liberated in juxtaposition with the hydrogenized palladium, unites with the hydrogen, and forms water, no material amount of oxygen appearing at the surface of the palladium until all the hydrogen has been removed from the latter.

If we watch the effect of the change produced in this way on the screen, we find that, according as the hydrogen is removed from the palladium, the needle begins to move from the position it assumed at *b*, when the spiral was charged with hydrogen, or alloyed with hydrogenium, if we prefer the term, until it returns to the starting-point *a*. Instead of resting there, as it ought to do, however, it travels on steadily until it reaches the position *c*; thus demonstrating the singular fact that the contraction of the palladium on losing its charge of hydrogen is *double* the amount of its previous expansion. Professor Graham accounts for this singular phenomenon by supposing that the particles of the metal slide over each other in a lateral direction, so that the band of the palladium is unusually shortened, though its density is not in-

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light, so that the latter may be reflected in a vertical direction, as indicated by the dotted line. Immediately above this mirror is placed on a wooden support the flat glass cell D, about an inch in depth, and of any required size. Above this vessel is placed a double convex lens, E; the height at which this must be placed above D will depend on the focus of the lens, and is readily found by ascertaining the point at which the image of the object placed in D is most clearly defined on the screen. The rays reflected from the first mirror, B, and having passed through D and E, now fall on a second mirror, C, by which means they are projected on to the screen, and, when the focus is properly adjusted by shifting E, a well-defined image of any object placed at D is shown erect on the sheet.

creased, since reduction in length is accompanied by a proportional increase in other dimensions.

It is found that this palladium foil charged with hydrogen possesses most powerful reducing properties; that the hydrogen within it is just as capable of reducing silver salts as a metallic layer of zinc would be. As illustrating this point, we may cite an experiment: A plate of palladium foil was charged with hydrogen, as above described, and then immersed in a solution of corrosive sublimate; almost immediately a white precipitate of calomel made its appearance, and, when the action proceeded a little further, mercury was reduced. On repeating this experiment with a slightly alkaline solution of nitrate of silver, the metal was quickly thrown down on the palladium plate, and, when an alkaline solution of gold was used, the metal was likewise precipitated. These precipitates were obtained under circumstances in which the ordinary hydrogen gas or palladium foil alone would have been quite incapable of effecting reduction.

We have already seen that hydrogen can be liberated from the charged palladium by presenting to it oxygen *in conditione nascenti*, but it can also be set free by heat, or by reduction of the pressure of the atmosphere surrounding the charged plate. If a palladium wire be made to absorb as much hydrogen as it can take up, and if the tip of the wire be heated in the flame of a spirit-lamp, hydrogen gas is liberated, and burns on the surface of the palladium, the flame continuing until all the gas has been set free. Again, if a similarly charged wire be placed under the receiver of an air-pump and the air exhausted, the hydrogen is completely liberated in its ordinary gaseous condition.

In order to complete this account of hydrogenium, it is only necessary to mention that its density is stated to be nearly 2, or about equal to the specific gravity of the metal magnesium; but the means by which Professor Graham has arrived at this result, though very ingenious, are so unsatisfactory that we must take this estimate as being a mere approximation to the truth. In all probability we must wait for the accurate determination of the specific gravity of hydrogenium until the metal itself will have been isolated in a pure condition.

Thus, in the course of this lecture, we have liberated hydrogen, "*as a gas*," from water, and in this condition have studied some of its properties. Again, we have made this remarkable element alloy itself with palladium; and when thus appearing in the guise of "*a metal*," we have noted the chief phenomena it gives rise to. And now, like the bird from its cage, we will set free this hydrogen from its prison-house of palladium, and let it mingle with the mighty aerial ocean in which we live and move.

A LECTURE ON THE IDENTIFICATION OF THE ARTISAN AND ARTIST.

By Cardinal Wiseman.

[In the spring of 1852 an association was formed by the Catholics of Manchester and Salford, in England, to raise funds for the education of the poor. The committee, in aid of this purpose, invited Cardinal Wiseman to deliver an address upon some literary subject of general popular interest. The invitation was accepted, and the following admirable address, for a copy of which we are indebted to a friend, was delivered in the Corn Exchange, Manchester. We have thought that a more general diffusion of it would be acceptable to those who are interested in the establishment of schools of art in this country, and accordingly have given it a place in this report.—J. H.]

Ladies and Gentlemen: I ought certainly to commence my address to you by thanking you for the extremely kind manner in which you have been pleased to receive me; but I feel that I must not waste your time in mere expressions of a personal character, feeling rather that I shall have to tax your time and your attention to a considerable extent. I will, therefore, enter at once upon the proposed subject of my address, which has already been communicated to you by my old and excellent friend, the Bishop of Salford. And I am sure I need not say, for he already has well expressed it to you, that it is a topic which at the moment has engaged its full share of public attention, as drawing to itself the interest of all the educated classes, and it is in fact a topic connected with important questions, the solution of which may have to exert an important influence not only on our social but likewise on our moral progress.

The topic on which I have to address you, then, is the connection or relation between the arts of production and the arts of design.

By the arts of production, I mean naturally those arts by which what is a raw material assumes a form, a shape, a new existence, adapted for some necessity or some use in the many wants of life. Such is pottery; such is carving in its various branches, whether applied to wood or to stone; such is the working of metals, whether of gold or silver or brass or iron; such is the production of textile matters, of objects of whatever sort and for whatever purpose; such is construction in its different branches, commencing with the smallest piece of furniture, and ascending to a great and majestic edifice. By the arts of design, I understand those which represent nature to us in any form, or which bring before us beauty, whether in form or in color.

Now, these arts ought, as every one agrees, to be in close harmony one with the other; but that harmony which I wish to establish between them must be an honorable union, an equal compact, a noble league.

There is not to be one the servant, and the other the master; each must be aware of the advantages which it can receive as well as those which it can confer. Thus the arts, for instance, of design, will have to give elegance of form, grace of outline, beauty of ornament, to that which is produced by the other class of arts; and they in their turn have to transmit and multiply and perpetuate the creations of the arts of design. Now, it is agreed on all hands that as yet this complete harmony does not exist; that we have far from arrived at that mutual application of the one class to the other which gives us a satisfactory result. It is unnecessary, I believe, to bring evidence of this. As we proceed, I trust that opportunities will present themselves of bringing before you authorities for that assertion. But I may say, at the very outset, that the report which is published by the department of practical art is almost based upon the acknowledgment that as yet we have not attained that application of the arts of design to the arts of production which we desire, and which is most desirable to the arts of production to obtain. It acknowledges the existence of a necessity for much more instruction than has yet been given. It allows that for several years—thirteen years, at least—of the existence of schools of design they have not been found fully to attain their purpose, and a new organization and a new system has now begun to be adopted. No one can appreciate, I trust, more than I am inclined to do myself, the advantages which must result from the multiplication of these schools of design as applied to manufactures, and other great improvements which they have already begun to confer, and will continue, no doubt, still more to bestow upon the industrial classes. I believe it most important to propagate to the utmost the love of science, the love of art. *I believe it most useful to accustom every child to its first rudiments, its elementary states.* I think, if we can make drawing a part of universal education, a great deal will be gained. But this, certainly, cannot be enough. I am willing to grant that we shall have a great improvement upon what we have produced in the form of art. I believe that we shall see better designers; men with better imaginations; men who understand the harmony and combination of colors better, and who can give to the artisans patterns which will greatly improve every department of our industry. But, I ask, is that sufficient? Will this bring art up to what we desire? This is the great question. This is the subject of which I am going to treat. It appears to me that there is a very simple mode of looking at it; and it is the one, consequently, which I shall adopt. It is a question partly of experience. It is a lesson much of which history can teach us; and I desire to bring before you such facts as seem to me to bear upon the question, and to enable us to come to a practical and satisfactory conclusion. I will endeavor to state the question under a very simple, but, perhaps it may appear, not a very practical form.

There is now a great desire to form, not only in the capital, but also in all great cities where industry prevails, museums, which should

contain all the most perfect specimens of art antiquity in every age has left us of beauty in design and elegance in form. We wish that our artisans should have frequently before them what may be considered not merely actual models to copy, but likewise such objects as may gradually impress their minds with feelings of taste. Now, I should like to have the construction, the forming, of such a museum. And, in describing it, I will confine myself entirely to one small department—that of classical art, classical antiquity—because I know, that, for a museum intended to be practical to the eyes of artisans, there is a far wider range of collection to be taken than that to which I will confine myself. Well, now I imagine to myself a hall at least as large as this, and of a more elegant and perfect architecture. I will suppose it to be formed itself upon classical models; and around it shall be ranged, not merely plaster casts, but real marble statues and busts collected from antiquity. I would range them round the throne so that each could be enjoyed at leisure by the student. There should be room for the draughtsman to take a copy from any side. In the center I would spread out a beautiful mosaic, such as we find in the museums, for instance, of Rome, a pavement in rich colors, representing some beautiful scene, which should be most carefully railed off, that it might not be worn or soiled by the profane tread of modern men. There should be cabinets in which there should be—but inclosed carefully with glass, so that there would be no danger of accidents—the finest specimens of the old Etruscan vases, of every size, of every shape, plain and colored, enriched with those beautiful drawings upon them which give them such rich characters, and at the same time such price; and on one side I would have collected for you some specimens of the choicest products of the excavations of Herculaneum. There should be bronze vessels of the most elegant form and the most exquisite carving, and there should be all sorts even of household utensils, such as are found there, of most beautiful shape and exquisite finish. On the walls I would have some of those paintings which have yet remained almost unharmed after being buried for so many hundred of years, and which retain their freshness, and would glow upon your walls, and clothe them with beauty, and at the same time with instruction. And then I would have a most choice cabinet, containing medals in gold and silver and bronze, of as great an extent as possible, but chiefly selected for the beauty of their workmanship; and engraved gems likewise, every one of which should, if possible, be a treasure. Now, if such a museum could be collected, you would say, I am sure, that so far as classical antiquity goes—classical art—you have everything that you could desire, and you have as noble, as splendid, as beautiful a collection of artistic objects as it is within the reach of modern wealth and influence to collect. In fact, you would say, if you could not make artists now by the study of these objects, it was a hopeless matter, because here was everything that antiquity has given us of the most beautiful.

Now, I am afraid that, while you have been following me in this

formation of an ideal museum, you have thought it required a great stretch of imagination to suppose it possible that such a collection could be made in any city of England. I will ask you, then, now to spread your wings a little more, and fly with me into even a more imaginary idea than this. Let us suppose that by some chance all these objects which we have collected were at some given period, in the first century of Christianity, collected together in an ancient Roman house; and let us suppose that the owner of the house suddenly appeared among us, and had a right to claim back all these beautiful works of art which we so highly prize, which we have taken so much trouble, and laid out so much money, to collect. Now, what does he do with them when he has got them back? What will he do with these statues which we have been copying and drawing and admiring so much? Pliny finds great fault, is very indignant with the people of his age, because he says they have begun to form galleries, *pinacothecas;* that such a thing was unknown before; that no real Roman should value a statue merely as a work of art, but that it was only as the statue of his ancestors that he ought to value them. And thus that Roman looks at them as nothing else. He takes them back; he puts the best of them, not in the center of a room where it may be admired; but to him it is a piece of household furniture, and he puts it with all its fellows into the niches from which they have been taken, and where they are, perhaps, in a very bad light. It is exceedingly probable that if the statues were not of his ancestors, he would, instead of allowing them to remain in the beautiful hall prepared for them, send them into his garden, into his villa, to stand out in the open air, and receive all the rain of heaven upon them. The mosaic which we have valued so much, and which is so wonderful a piece of work, he will put most probably into the parlor of his house to be trodden under foot by every slave that comes in and goes out. And now he looks about him at that wonderful collection of beautiful Etruscan vases which we have got together, and he recognizes them at once: "Take that to the kitchen; that is to hold oil:" "Take that to the scullery; that is for water:" "Take these plates and drinking-cups to the pantry; I shall want them for dinner." And those smaller, those beautiful vessels, which yet retain as they do the very scent of the rich odors which were kept in them, "Take them to the dressing-rooms; those are what we want on our toilet, This is a washing-basin which I have been accustomed to use. What have they been making of all these things, to put them under glass, and treat them as wonderful works of art." And, of those beautiful bronze vessels, some belong again to the kitchen, others belong to our furnished apartments; but every one of them is a mere household piece of furniture. And then he looks into the beautiful cabinet; and he sends those exquisite gems into his rooms, to be worn by his family, as ordinary rings. And your gold medals and silver medals and bronze medals he quietly puts into his purse; for, to him, they are common money. Now, then, here we have made a collection of magnificent productions

of art; and, in reality, these were all the fruits of the arts of production.

Now, what are we to say to this? We are to say that *there was a period in Rome, and there were similar periods in other countries at different times*, when there was no distinction between the arts of production and the art of design; but those very things, which to us now are objects of admiration as artistic work, were then merely things made and fashioned as we see them for the ordinary uses to which we adapt other things of perhaps similar substances, but of a very different form. For, in fact, if you had these vessels, you would not know what to do with them. We could not cook a dinner in them. We certainly could not adapt them to our common wants. But to the Romans they were the very objects which were used for those purposes; and although now, in reading the old writers, and trying to make out the dreadfully hard names by which all these different pieces of pottery are called, yet, learned and classical as all that may be, when we come to translate these high-sounding Greeks names into English, we get very modest results—pipkins and basins and ewers and flagons, and such homely names as these. Now, where is the art there? Is it that these were designed, do you think, by some man of great reputation; and then that they were all carefully copied, exactly imitated, from his design? Oh, certainly nothing of the sort. The art that is in these beautiful things is a part of themselves; is bestowed upon them in their fabrication. You may take the Etruscan vase, and you may scratch away from it, if you please, every line which had been traced by the pencil of the embellisher upon it; and, after that, the seal of beautiful design, grace, and the elegance of true art are so stamped upon it, that, if you wish to remove them, you must smash the vase. It is inherent in it; it was created with it.

Then what I fancy is desired is, that we should bring art back to that same state in which the arts of design are so interwoven with the arts of production that the one cannot be separated from the other, but everything which is made is by a certain necessity made beautiful. And this can only be when we are able to fill the minds of our artisans with true principles, until really these have pervaded their souls, and until the true feeling of art is at their *fingers'-ends*. You will see, I think, from the example which I have given you, what is the principle at which I am aiming; which I wish to establish. It is this: That at any period in which there has been a really close union between the arts of production and the arts of design, *this has resulted from the union in one person of the artist and the artisan.*

Such now is the principle that I am going to develop; and in doing so I will distinguish between arts of production belonging to two distinct classes. There are those in which necessarily there is manipulation—the use of the hand, or of such implements as the hand directly employs; and there are those in which mechanical ingenuity is employed in the art of production. It is clear that these two must be treated distinctly; and I will begin with the first, which affords the greatest

number of illustrations and examples, in proof of that principle which I have laid down.

I will begin first, then, with illustrations from metal work. Now, the period in which there was the greatest perfection in this sort of work, as is universally acknowledged, is from about the fourteenth century—1300, I think to 1600, or at least after 1500. It is singular that, in that period, five at least, very probably more—but we have it recorded of five of the most distinguished sculptors whose works are now the most highly prized, that they were ordinary working goldsmiths and silversmiths. This is given us in their respective biographies: Benvenuto Cellini, Luca della Robbia, Lorenzo Ghiberti, Brunelleschi, and Baccio Bandinelli, all of whom were goldsmiths and workers at first, developed most extraordinary talent as sculptors. How was this done? Can we conceive a person who is merely a workman, working upon such plate as is put before him, becoming a man of high first-class character in art? There have been examples, but they are rare. But here we have five men, in a limited period, becoming most eminent. Now, what was the reason of that? It was because the jeweler, the silversmith, who worked with his hands, was educated, not only as an artist, but an artist of the highest class; and Vasari observes, in the life of Bandinelli, that in those times no man was reputed a good goldsmith who was not a good draughtsman, and who could not work as well in relief. We have a principle then established, that the person who did the material work in the finer works was an artist, who could not only draw, but model, and did the same with the metal itself; for that is the nature of that class of work of which I have spoken.

Now, take the life of Cellini. Here was a man who originally was put to a totally different employment. His father had no higher ambition concerning him than that he should become a great player upon the flute; and he teased him during all the last years of his life because he had no taste for this, and would run after goldsmiths and others, and learn the different branches of their profession. He led the most wonderful life. He was to day at Rome; next day at Florence; then he was at Naples; then at Venice; then in France; then back again: that he could have done any work, in fact, seems incredible to any one who reads his life. And he did not travel by train or any public conveyance which could take on his luggage. He traveled on horseback each time, from Rome all the way to Paris. He had no luggage; he was a poor man, and whenever he came and started his shop, he began by making his own tools; and he worked with his scholars, who were generally young men that became themselves eminent in the profession, in a little open shop, looking to the street; there he himself hammered and carved and cast and shaped, and did whatever else was necessary for the work. He was an actual working goldsmith; and the beauty of his works consists in this, that they have the impress of genius so marked upon them, that they never could have been designed by one person and executed by an-

other. There is as much art in the finish by his own hand, in every enamel, in the setting of every stone, as there is in the entire design; nor does he ever dream of talking of himself in any other way; and yet how he went on from step to step, until at length he produced the most magnificent works, on the largest scale, in marble and in bronze! He describes how he constructed his own Perseus. He went to buy his own wood, and saw it brought; and when he was casting that most exquisite statue of Perseus, which is still one of the wonders of art, he had every sort of misfortune. His furnace blew up, the roof was blown off, and the rain came in torrents upon the fire just the moment that the metal was going to be poured in. By his ingenuity, his extraordinary contrivances, he baffled, it might appear, the whole chain of accidents, and brought out, almost without a flaw, that most perfect piece of workmanship. You may imagine to what a state he was reduced, when, the very moment that the metal was ready for pouring out, the explosion took place. He had no other resource but to run to his kitchen, as he says, and to take every piece of copper, to the amount of two hundred porringers and different sorts of kettles, and throw them into the fire; and from these that splendid statue came forth. There was genius.

As a curious instance of the most extraordinary ingenuity, he tells us that on one occasion a surgeon came into his shop to perform an operation on the hand of one of his pupils. Upon looking at his instruments, he found them, as they were in those days, so exceedingly rude and clumsy, that he said, "If you will only wait half an hour, I will make you a better instrument;" and he went into his workshop, and took a piece of steel, and brought out a most beautifully finished knife, with which the operation was successfully performed, Now this man, at the time you see him thus working in his shop as a common workman, was modeling in the most exquisite manner in wax; spending his evenings in the private apartments of the Grand Duke, modeling in his presence, and assisting him with a hundred little trifles which are now considered treasures of art. And so wherever he was, and under all circumstances, he acted as an artist, but at the same time as a truly laboring artisan. It was the same with others in the same profession. He was not the only man, by any means, whose genius was so universal; because we find him telling us repeatedly that the moment he heard of some goldsmith (and in those days a goldsmith was really an artist, as I have already said) who excelled in any particular branch of art, he determined to excel him. Thus it was that he grew to rival the medals of one, the enamels of another, the peculiar manner of putting foil to precious stones of another; and, in fact, there was not a branch of art which he did not consider it his duty to excel in. With this spirit, is it wonderful that men of really great taste should have been produced? men who, you observe, looked upon every branch of productive art as really a branch of the higher art of design; and thus in their own persons combined that art with the power of the tool; were artists as well as artisans.

There is another celebrated jeweler of that time, whom he mentions frequently, of the name of Antonio Foppo, a Milanese, who is better known in the history of art by a name which he received in derision in Spain, the name of Capodursa, which means a bear's face, and which he is known by, commonly, in works of art. Cellini describes to us the processes by which he produces his works; and they are so careful, and require such accurate knowledge of art, that his knowledge must have been very superior indeed in the arts of design. As an instance of what was the latitude and the extent of art, and how really a jeweler or goldsmith in those days was not above work which in our days no one would dare offer to a person of such a profession, we have a case recorded in the history of one of the painters, Pierino del Vaga, by Vasari, speaking of a very particular friend of Pierino's, a goldsmith. When the Grand Duke of Tuscany was building his palace, he gave to this man a commission to make the metal blinds for the ground floor of that palace; (and it is considered a great pity that a work of so homely a nature should have perished, because there can be no doubt whatever that it was a work of exquisite beauty.) So that, even upon what would be considered the lowest stage of common production, the artist did not feel it was beneath him to design; not to give a design to others, but to execute it himself. We have in the collections, particularly of Italy, in the palaces, evident proofs of the great extent to which this combination of various arts must have been carried, in works exceedingly complicated, extremely beautiful, and at the same time necessarily requiring a great deal of ability to execute. Those are the rich cabinets in which may be found, mixed together, work in marble, and in ivory, in wood, in metals, in enamel, and in painting, all combined together by one idea, and all executed by one hand, but of the authors of which it seems impossible to find any good trace. They probably were produced by those men called goldsmiths, and who, as I said before, could work as well upon any of those substances, and thus bring them harmoniously to form one beautiful whole.

Now, proceeding from what is most precious in art to what is more homely, let us return for a moment to a subject on which I have already touched. I have spoken of the beauty of the productions of antiquity in metal, which were found in the excavation particularly of those two buried museums, as we may call them, of antiquity, Pompeii and Herculaneum. The collection of these is chiefly in Naples. Except where presents have been made to other countries, they have been jealously kept together. Now, these different objects have not been dug out of temples or out of palaces, but they have been taken out of every sort of house—houses evidently belonging to the citizens—and I think you may see that there is not one in that collection which does not immediately arrest the eye both by the beauty of form and by its exquisite fancy. Many of them have been engraved in the publication called the "Museo Borbonico," the Bourbon Museum, the Museum

of Naples; and I think very justly the remark is made by the editor in the fifth volume, that the whole modern civilized world, however vast it may be, and however it may labor in so many arts and so many trades, does not and cannot exhibit even a small proportion of that elegance and ornament, varied in a thousand ways, and in innumerable most fantastic modes, which are to be admired in the remains of furniture found in Pompeii and Herculaneum—two cities which occupied so insignificant a place in the ancient world. That is quite true. Now, what are we to infer from this? There can be no doubt, as I have said, on examining these beautiful objects, that they have been for common use. There are scales, steelyards, which can only have been made to weigh provisions; the chains are most delicately worked; the weight is frequently a head with a helmet, most beautifully chiseled; and so genuine and true are these, so really intended for every-day use, that one of them has stamped upon it yet, the authentication made at the capitol of the weights being just. This was a steelyard which was in the kitchen, and it was for the ordinary purposes of the house. There are other large vessels which must have served for culinary purposes, and of which the handles and the rings and the different parts are finished far beyond what the finest bronzes that are made now in Paris can equal. What are we to conclude? You do not suppose these were the designs of the Flaxmans and the Baileys of that day. Who ever heard of a great artist in Pompeii and Herculaneum? And how can you imagine that every house furnished itself with what were considered exquisite and extraordinary specimens of art for the use of their every-day life? And then, where are their common utensils, if these are not they? If these lamps were not what they burnt, if these candelabra were not the shafts upon which they were hung, if these vessels were not those in which they prepared their viands, where are those? Were they carried away in the flight? But the most precious would surely be carried away, and the commoner be left behind. Nothing of the sort. One may see here everything is to be found; and everything is beautiful in shape, and generally in finish. What are we to conclude? Why, nothing less than that the braziers who made these things were able to make them. They came from the hands of the brass-founder; they have been chiseled in the workshop; they have been finished, not to be put up in cabinets, but in order to be knocked about by servants. Then here we have a state of art in which the producer, the man who makes, who manipulates, who handles the object of manufacture which he produces, was able to do what now defies almost our most superior workmen.

Now let us go to another part of the world, and come to a later period. Nuremberg, during the time which I have specified—between 1300 and the middle of 1500—was a center of art, and especially in all metal work. There is an observation of Hoffman, a German writer, that Nuremberg was the city in which the artist and the crafts-

man walked most harmoniously hand in hand; but I think he does not go far enough; he ought to have said that it was a city in which *the artisan and the artist were the most perfectly combined.* At a very early period, that is, as early as 1355, there was produced a piece of work such as is at this day the admiration of all artists. And what was it? It was a mere well, a fountain in the public square; "the beautiful fountain," "the beautiful well," as it is to this day most justly called. Now, this was made entirely by the designer, by the artist himself, Höfer, who united in himself these two qualities; and it is acknowledged that in the treatment of the metal work, and in the beauty of the religious images which surround this fountain, but few steps have been made in art since that time. And he, as I observed, was a mere workman; he did his own work. At a later period—at what is considered the third period of art, in Nuremberg—there is another remarkable piece of metal work; and I am glad to find that in the last report just published by the department of practical art, Mr. Smirke has introduced a letter in which he begs that this piece of workmanship, which he calls one of the most celebrated productions in metal, may be copied by casts, and brought to England as a specimen of art. Now that beautiful production was of as early a period as 1506; it was made between 1506 and 1519, and it is the shrine of St. Sebald, in his church at Nuremberg; an exquisite piece of work—so beautiful, so elegant, as that no iconoclasm had dared to touch it (though I must say that Nuremberg had been preserved from the reproach of that error)—but there it is, in its freshness and its beauty as it came from the artist's hand; in the center, a shrine of silver, in which is the body of the saint, and around it what may be called a cage or grating of the most perfect metal work, and with statues of most exquisite workmanship. Now I do wish this to be brought to England—a copy, that is, of it—not merely because it will show what was done in ages that we consider hardly emerging from barbarism; not only what beautiful inspirations religion could give the artist; but because it will show to those who are trying to raise the character of any art *the true principle upon which alone it can ever be raised to what it was then.* They will see the artist portrayed upon it—Peter Vischer; they will see him with his apron on; they will see him with his chisel and his mallet in his hand; they will see that he aspires to nothing more than to be a handicraftsman, a workman in metal, who yet could conceive, and then design, this most magnificent production of man's hand.

Another example, something of the same sort, we shall find in a neighboring country. There is at Antwerp, likewise, a beautiful well near the cathedral; and if you ask who it was that produced this, you will hear that it was one who sometimes had been known as a painter, and at others, under the more familiar appellation of the "Blacksmith of Antwerp," as a blacksmith; and there is a piece of iron-work which I fear that not our most perfect works could turn out—certainly not, nothing that could be compared with it. And Quintin Matsys was

a poor school-boy, who, finding the heavy blacksmith's work too much for him, took to drawing and coloring little images of saints, to be given out in processions, and thus rose to be a painter and an artist, finding his first profession too heavy for his strength. But this iron-work is a work of art; it is not a work merely cast in the lump, and then put together; but it is a work that required genius, that required great artistic skill; it shows that the artist even worked in iron; that a man who belonged to the very lowest branch of what may be considered the arts—laboring in metal—was able, notwithstanding, to imagine and to carry out the most beautiful conceptions.

Now, coming to modern times, do we find anything of this sort? I content myself with referring to that last report which I have just mentioned—of the department of practical art. In that report there are incorporated letters from some of our best silver and goldsmiths upon the character of the artistic proficiency of the workmen. I will only read one, for all in reality repeat the same sentiment. "At present we seldom find an English workman who understands drawing. Not one of our English workmen has a knowledge of drawing;" and it is said that, without exception, these men will not even go to the school. Attempts have been made to bring them to the school of practical art, that they may learn something of the principles by which the works in their branch of productive art should be conducted. They cannot be induced to go and obtain that information, though it is nearly, or entirely, gratuitously given. So little taste, so little feeling of art is there in our workmen now. Can we expect they will produce works that will rival those of ancient times? For there is this broad, immense difference: in one, the artist was the workman; now, the workman has only a degree of intelligence above the machinery which he uses. He can apply those means which are put into his hand; but can have no artistic feeling to give the last touch, or even to bring things to ordinary perfection. On the other hand, we must be struck with the difference, that in France there is much more taste, much more knowledge, much more intelligence, in the actual artificer; the exhibition showed, that, though we had magnificent things in silver-work, and gorgeous objects in metallic productions, beautiful and splendid, yet, when you came to look at them with the artist's eye, you could not help observing the immense difference between our English productions and those of France; though, be it spoken to the glory of our English goldsmiths, they have both the taste and the generosity and munificence to bring over and to employ the very first foreign artists; and it was thus we did produce some objects that stood in competition, not with those of the workman's rivals, but with those of his own countrymen.

In Vecht there is an example of what the artists in old times were. He began as a cotton-spinner; he became a manufacturer of toys; then a button-maker; and then he began to work with the chisel. His genius developed itself. He began to retouch and repair ancient armor,

and then was tempted, seeing that these were things sought after, (it appears with the most honest intention,) to imitate them; and he found that they were bought and put in royal and imperial cabinets as real work of what is called cinquecento. And then he imitated the shields, working exactly upon Cellini's principle, that everything, however small, is worked out separately, and then fastened together; that nothing is cast, but that everything, to the smallest tip of the least finger, is hollow; and he worked on, and produced it by his artistic and careful manipulation. He began to work this way, and he found his silver-work also became considered as ancient, and was adopted into collections of valuable antiquities. He then learned the power of his own genius, and he soon rose; and, when the late revolution in France took place, he had commissions for works to the amount of £60,000. And this was all *his own* work, the production of *his own* hands. However, his losses were in common with many others who had engaged in higher branches of art, and he has been since in this country; but certainly those specimens of his work which we had in the exhibition were not only most beautiful, but most exquisite; and many persons who took the pains to examine in detail some of the works in silver, which were presented by one French house in particular—the Frères Maurice—must have been struck by the high artistic merit of them all. And they all are worked entirely bit by bit by the artist; and it was impossible they could be executed but by an artist who could model as well as draw, and who knew how to treat his metal perfectly, so as to give all the softness, beauty, and delicacy of the original model.

Now let us proceed to what may be considered a higher branch of art, and that is sculpture. We shall find exactly the same principle throughout; all the greatest artists of the most flourishing period were *men who did their own work.* You are probably aware—many, I have no doubt, are—at the present day, when a sculptor has to produce a statue he first of all makes his model in clay; probably a drawing first, then a small model, then a model exactly as he intends the statue to be, full-sized and completely finished; from this the cast is taken in plaster; the block of marble of proper size is put beside it, and a frame over it from which there hang threads with weights; these form the points from which the workman measures, from corresponding lines, first to the models, and then from these which are over the cast to the cast itself; and by means of the merest mechanical process he gradually cuts away the marble to the shape of his cast, and often brings it so near to the finished work that the artist himself barely spends a few weeks upon it. This was so much the case with a very eminent sculptor that it is well known he hardly ever had occasion to touch it.

Now that was not the way the ancients worked: they knew perfectly well that there was more feeling in the few touches which the master-hand gives, even from the very beginning of the work, than there can be in the low and plodding process of mechanical labor; and we find that

those who were really exquisite sculptors in ancient times *were also their own workmen.* Vasari tells us of Orcagna, that he made at Florence seven figures, *all with his own hand*, in marble, which yet exist. Now, Orcagna was certainly a remarkable person. He was a sculptor, painter and an artist: and so justly *vain*, if one may so speak, of this varied character of his art, that, upon his monuments or sculptures, he calls himself a painter; upon his paintings, he always calls himself a sculptor. His paintings are to be found in the cemetery at Pisa. The most beautiful and splendid of his works is the matchless altar in the church at San Michael, in Florence, of which, I am glad to say, there will be an exact copy in the future Crystal Palace. This artist, now, whose work is certainly most beautiful, most finished, as far as we can gather from his life, *actually did the work with his own hands, and carved the whole of the marble himself.*

I shall have occasion to speak of another celebrated artist under another head; and therefore I now will mention one who became very celebrated, and from whose life it is evident that he did the whole of the carving with his own hands, and that is Brunelleschi. He lived at the period when art was becoming truly most beautiful—the period which just preceded the appearance, perhaps, of a still greater artist, but who, in some respects, departed from the purest principles of art. He was the contemporary of Donatello, and they were both very great friends, and worked even in the same church. An anecdote related by Vasari, in the life of Donatello, will show us how truly Brunelleschi was not merely a sculptor, but a carver who performed the work with his own hand. He tells us that Donatello had received a commission to carve a crucifix, (which yet exists in the church of Santa Croce, under a beautiful painting by Taddeo Gaddi,) and that he produced what was considered a very fine work; but he was anxious that his friend Brunelleschi should see and approve of it. He invited him therefore, one day, to inspect it; which shows that the work had been covered up and concealed during the execution. Brunelleschi looked at it, and said nothing. His friend Donatello felt hurt, and said, "I have brought you here to give me your opinion; tell me candidly what do you think of it?" "Well, then," Brunelleschi said, "I will tell you, at once, that it is a figure, not of Christ, but of a peasant or a rustic." Donatello was indignant. It was perhaps the most beautiful specimen of the subject in carving that had been produced; and he used an expression which became a proverb; and I cannot help remarking how many expressions of artists have turned into proverbs. The expression in Italian means this: "Take a piece of wood, and make another." Brunelleschi did not reply. He went home. He did take a piece of wood. He said nothing to Donatello, and he carved his crucifix. When it was quite finished, he met Donatello, and said, "Will you come and sup with me this evening?" (Now I narrate this anecdote partly because it shows us what the great artists were—that they were not great gentlemen living in any

particular style.) "I will do so with pleasure," said Donatello. "Then come along;" and Brunelleschi, as they went on, stopped at the market, bought eggs and cheese for their supper, put them in an apron, and said to Donatello, "Now, you carry these to my house while I buy something else, and I'll follow you." Donatello entered the room, saw the crucifix, let fall his apron, and smashed the eggs. Brunelleschi soon followed, and found Donatello with his hands stretched out, and his mouth open, looking at this wonderful work. "Come," said he to Donatello, "where's our supper?" "I have had my supper," said he; "you get what you can out of what is left." And then, like a true, noble-hearted, generous artist, he took his friend by the hand, and said, "You are made to represent Christ; I, only to represent peasants." Now, this shows, as I said before, that this poor artist carried on his own work with his own hands, shut up in his own house; in fact, that, as Vasari tells us, he never allowed any one to see it until it was quite completed.

There can be no doubt that, among all the names celebrated in art, there is not one that can be put in comparison with that of Michael Angelo; a man who, not merely from his follower, disciple, and intimate, Vasari, but even from jealous and envious and ill-tempered Benvenuto Cellini, receives constantly the epithet of "the divine." No man certainly ever had such a wonderful soul for art, in every department: the cupola of St. Peter's, as an architect; his Moses and his Christ, as a sculptor; and his Last Judgment, on the ceiling of the Sistine Chapel, as a painter, are three monuments which would have made the eternal fame, not of three, but of a hundred, artists in each department. Great, noble, generous, and though perhaps somewhat in his temper not amiable, yet sternly honest in all his dealings, he seems to have been the great center around which the art of his period revolved. There was no one so great, so sublime in any particular branch of it, that did not look up to Michael Angelo, and consider him his superior. It is acknowledged that Raffaelle went into the Sistine Chapel, and saw Angelo's wonderful works, and changed entirely his style upon beholding them; and it is particularly acknowledged by the writers of that time, that in every other department—civil engineering, &c.—he was considered equally supreme. Now, you would suppose that this man, upon whom commissions poured in every day for great works, would have employed a number of artisans to assist him; that he would have had carefully prepared models, which he would have intrusted to skillful artificers, so as to lighten his labor. But no such thing. There is every evidence we can desire, that, from the beginning to the end, Michael Angelo performed the whole of his own work; that he began with the piece of marble as it came from the quarry; that, if not always, pretty generally, he did not even condescend to make a design beyond a small wax model, but immediately set to work with chisel and mallet on the figure which he had in his imagination, and which he knew was as truly lurking in the inanimate block. Vasari shows us, in fact, from his unfin-

ished pieces, in what way he must have mapped out the marble and done the work himself; and that is why we have so many vast pieces by him unfinished: either the stroke did not come out as he desired, or it went too far into the marble, and spoilt his labor. But so it is, that by far the greater part of those gigantic pieces which he finished, if not all, were the productions of his own hand, as well as of his intellect.

When about seventy-five years of age, Vasari tells us, he used to be just as indefatigable with his chisel and hammer as when he was a stout, young man. He had near his bed-room, if not in it, (for he lived in a most primitive and simple manner,) an immense block of marble, and, when he had nothing else to do, he used to be hammering at that; and when asked why he so continuously worked at this branch of his various arts, he used to reply that he did it for amusement, to pass his time, and that it was good for his health to take exercise with the mallet. He undertook at that age, out of an enormous block of marble, to bring out four figures, larger than life, representing the descent from the cross; and he had nearly worked out the figure of our Lord, when, happening to meet with a vein that was hard and troublesome, he one day broke it into half a dozen pieces. It was seen in this state by a friend, and his servant begged it for him. It was put together, and it is now to be seen at Florence. But Vasari says that it was necessary, in order to give him occupation, to get another large block of marble and put it near his bed, that so he might continue at his work; and he began another group of the same sort. This was at the age of seventy-five. And Vasari gives us an interesting account of how he worked: he says he was remarkably sober, and while performing his greatest works, such as the paintings, he rarely took more than a crust of bread and a glass of wine for his dinner. This sobriety, he says, made him very vigilant, and not require much sleep; and very often in the night he used to rise, when he could not sleep, and work away with his chisel, having made for himself a sort of helmet, or cap, out of pasteboard, and upon the middle of this, in the top, he had his candle, so that the shadow of his body never could be thrown upon the work.

Apropos of this, Vasari tells us an anecdote which is interesting as showing the character of Michael Angelo and of his time. Vasari observes that he never used wax candles for this purpose, but a particular sort of candles made of goat's tallow, which, he says, are particularly excellent. Wishing to make him a present, he (Vasari) sent to Michael Angelo his servant one day with four bags of these particular candles, containing forty pounds of them. The servant brought them; and Michael Angelo, who never accepted a present, told him to take them back again, he would not receive them. The servant said, "They have nearly broken my arm in bringing them, and I shall not carry them back." "Then do what you like with them," said Michael Angelo. "Then," replied the servant, "I observed, as I came to your house, that just before your door there was a nice bed of just-hardened mud: I'll go

and stick all the candles in this, and light them all, and leave them there." Michael Angelo said, "No, I can't allow you to make such a confusion as there would be about my door; so you may leave them." This shows the homely and friendly way in which the artists lived among themselves.

We have a very interesting account of the manner in which he used to work at his marble, from a contemporary French writer, who says: "I can say that I have seen Michael Angelo, when he was about sixty years of age, and not then very robust, make the fragments of marble fly about at such a rate, that he cut off more in a quarter of an hour than three strong young men could have done in an hour—" a thing almost incredible to any one who has not seen it; and he used to work with such fury, with such an impetus, that it was feared he would dash the whole marble to pieces, making at each stroke chips, of three or four fingers' thick, fly off into the air;" and that with a material in which, if he had gone only a hair's-breadth too far, he would totally have destroyed the work, which could not be restored like plaster or clay.

Going now to another part of the world for the same art, we return to Nuremberg, and find a most magnificent piece of sculpture in stone, unrivaled in the delicacy and exquisite beauty of the work; that is the tabernacle in the church of St. Lawrence. It rises from the ground and goes up, not merely to the top of a very high church, running along like a plant, with one of the pillars against which it is built; but, as if the church was not high enough for it, creeping far beyond, and making the most graceful termination, which has nothing similar in works of this sort. So beautiful and delicate is the whole work, representing all the mysteries of our Lord's life and passion, that, for a long time, people used to assert that it was not stone, but modeled in some composition. But it has been proved beyond doubt that it is stone. Now, the man who made this was a mason—*a common working stone-mason*—Adam Kraft, who built part of the tower of the church, and whose name is upon it as the mason who built it; and he, until 1490, when he was fifty-three years of age, had never attempted to work as a sculptor; and yet, before he died, he had not only executed many beautiful works, and among them a carved staircase in the tower, but this exquisite work, which is without a parallel. He has represented the whole of it as supported by three kneeling figures, himself and his two apprentices, who executed alone the whole work.

We see, therefore, that wherever there has really been grand or noble work executed by sculptors, *they have been artificers as well as designers; they have done the work with their own hands, as well as imagined it in their own fancies.*

Let us go now to another department of art. We have treated of metals and carved work in wood and stone. Let us now go to pottery. I have already observed that those beautiful vases, known by the name of Etruscan, were really made originally for domestic use; that, consequently,

they were made by the potter, and not by a fine artist only. This has been fully proved. It used to be thought at one time that they were all funereal, or of symbolical use, being found almost entirely in tombs; but it has been proved that the greater part of them were for the common domestic purposes of the table and the household; that some, indeed, were given as prizes at the games, filled with oil; others were marriage presents, kept with more care in houses, but still they were the work of the potter, and must have been produced entirely by hand. Pottery was so much considered as a branch of art, that in early Rome, in the time of Numa, there was a college of potters; they were ennobled by being made a special guild. Any one who went through the exhibition must have been particularly struck with the elegance of forms which prevailed in all the Indian and also in the Turkish pottery; and the common vessels, used to carry water on the head by the peasantry of Italy and Spain, have the same elegance of form which very little of our china, or of our finest pottery, can exhibit; and the question naturally suggests itself, how is this, that in many countries there should be such beautiful productions, and at the same time that we should not be able to give the same beauty of form? The answer to this is given, I think, very correctly by Mr. Digby Wyatt, in his beautiful work on the late exhibition. He observes that "there can be no doubt that the reason of this beauty in the old pottery and in that of the East is, that *it is made entirely by the workman himself.*" There can be little doubt that the most beautiful forms of Greek and Etruscan vases have been generated by a simple process of formation, and by the refined delicacy of touch acquired by the potter during *years of practice.* The perfect outline of some of the commonest objects of pottery from India, Tunis, Turkey, and the rest, demonstrate the methods by which contours equal in grace to the Etrurian and those of Magna Græcia have been produced. In the finer work of pottery among us, a distinct person is employed to design from him who makes the object; the one makes the pattern, and a mold is then made of the same figure as is given. But in the ancient and oriental objects, the beauty of form is attributed to *the art being literally in the potter's fingers;* and he acquires by the manipulation a fineness of touch, a delicacy of eye, which enables him to produce beautiful forms, which *no one in the abstract* could imagine." This is corroborated by the fact that in the British Museum, in the great gallery where the Etruscan vases are kept, you will find two—and if you search the Vatican and Bourbon Museum, and all the collections in Europe, you will not find two—perfectly alike; there is a difference in them, which shows they were not produced by a model, but simply out of hand; and I have no doubt that the influence of this working in clay without a pattern is to be traced in all the works in metal and in glass of the ancients; because, no doubt, the eye of the man who worked in bronze had been formed by his familiarity with the beautiful patterns which came forth every day from the hands of the workmen in clay. I find, too, it is mentioned

in Pliny, that when a knight named Octavius, in the time of Augustus, wished to have a vase made, it cost him a talent, or upwards of £50, to have the model made; which shows that the clay model was to be modeled before the marble vase was sculptured. In this art, then, the producer is the designer, the artist is the artisan, *and hence comes perfect beauty.*

Next to this must be mentioned a very important branch of productive art, in which the art of design is always necessary to be in combination with the actual manufacture; and that is china, or painting upon pottery. The Etruscan vases are often simple, sometimes of one color, sometimes they have nothing of ornament; at other times they have most beautifully executed, though sketchy, scenes of ancient mythology, or very frequently from the "Iliad." These are done in a way which shows there must have been hundreds of artists who could do that work. Very frequently it was not a painter who did them, but the man who was at work on the pottery throughout; and, although mere sketches, they are considered as containing the elements of very beautiful drawing. If we come to speak of the art of modern times, a remarkable instance of genius persevering in its work may be taken from the history of Bernard Pallissy. He was an artist, but as a painter of comparatively humble pretensions; for he tells us he used to paint figures, images, and so on; but in this he was an artist, to a certain extent. He tell us himself, in the biography he has written, that in 1544, when there seemed not to have been anything approaching to ornamental pottery in France, he happened to see an Italian cup, which struck him as being very beautiful; and he thought to himself, "Why could not this be produced in France?" He set to work. He was a poor man, hardly educated; but he had a great turn for chemistry, and was particularly desirous of finding out a manner of enameling pottery, and especially a white enamel, which he at length contrived to make. He took his worked to be baked in glass-houses, and found it completely fail; then he set to work in his own house, and built a furnace for the purpose. He put his ingredients into the furnace; they would not set nor harden. He had spent all his money, and he gradually pawned all his clothes, and burnt every article of furniture, to keep up the furnace, and pulled up the fruit trees in his garden, and then the very floor of the house, to keep up the fire. Still the work was all spoiled. When he went out the people charged him with being a coiner; he was ridiculed as mad; and every sort of annoyance came on him. He persevered yet; and, having found that his furnace would not act, he pulled it down, and with his own hands bringing the lime and bricks, he built another furnace, and then sat for six days and nights watching the fire. Then he got a little money by having a commission to make a survey, and came back to his work, and tried again. The mortar he used, however, happened to have some deficiency in it; and, just as the pottery was going to set, he heard a crack, and the pebbles in the mortar began to fly and broke

his enamel. He set to work again, and put his materials again in the fire; and this time there was a tremendous explosion, the ashes burst in and the whole of his work was covered with black, so firmly set into the enamel that it all had to be thrown away except a few pieces, by which he made a trifle. For sixteen years he persevered in this way, and then was crowned with success, and produced the finest specimens of colored and beautiful pottery, such as are to this day sought by the curious; and he received a situation in the king's household, and ended his days in comfort and respectability.

I could mention the beautiful earthenware of the sixteenth century, known by the name of "Raphael's ware," because it is supposed that Raphael himself did not disdain to make designs for common pottery, pottery not to be used merely by the rich, but to be found in the common cottages and houses of ordinary classes; the most beautiful specimens being in the apothecaries' shops of Padua and Verona. There we have the employment of high art in the decoration of a common and ordinary object; for the pottery itself has no particular pretensions to elegance of make, but yet one of these plates, thick, heavy, clumsy, and coarse as they are, is worth a service of modern production as a work of art.

Another department is statuary in pottery, which presents some very interesting features in the history of art. Its very origin is exceedingly interesting. Pliny gives it to us as the invention of a certain potter, of very ancient date, whose daughter, when parting with a youth to whom she was engaged, did what I dare say some of you have done, made him stand before the lamp, so as to throw his shadow on the wall, and so sketch his head and face; and the father, wishing to preserve this sketch, took some of his clay, and filled up the outline, and made a bass-relief of the countenance. That piece of pottery, at the time when the Romans first became acquainted with art, and carried away the monuments of Greece, was preserved in the temple of the Nymphs, at Corinth, as a treasure of art—as the first germ from which had been developed some of the most beautiful productions of that kind. At the time of the Roman kings of the race of Tarquin, the inhabitants of Italy had arrived at such perfection in this art that they used to make chariots, horses, and other representations of clay, so well baked that they could be placed in the open air, and stood for many centuries without injury; and, in fact, we find them now among Etruscan monuments. The Romans must also have learned well how to paint them; because we find it stated that there was an artist, whom Varro particularly mentions, who imitated fruit in pottery so perfectly as to deceive any one, and make one think it was real.

But the most interesting example of this application of high art to such products is what we find in the life of an eminent artist, and at the same time a potter, Luca della Robbia. He was put, when quite a boy, apprentice to a jeweler. He very soon began to make things in bronze; he gave up mere small modeling, and began upon marble, and succeeded

very well. He worked the whole of the day at his chiseling, and sat up all the night drawing. He was poor; he was hungry and cold; and the only means he had of warming himself at night was to put his feet in a basket of shavings, while he sat there drawing, and would not be driven from it. Now, there was an education for him, beginning first with small work, and exercising his patience and skill in that way. Sigismund Malatesta, the great patron of art at Rimini, was then building a splendid church, and he sent to Florence to find workmen to do the carving: and Luca della Robbia was engaged for this purpose. He had at that time been a silversmith's apprentice, had executed works in marble and bronze, and was set to undertake that noble work at Rimini; and how old was he when Sigismund engaged him? He was *fifteen!* And what pains and study must have been gone through in that time by the poor boy to make himself really an artist! He succeeded admirably at Rimini, and came back and received a commission to work with Donatello, to make a screen for an organ, and a bronze door. After all this, he suddenly discovered a totally new branch of art—modeling in pottery. He first contrived to manufacture his own clay; he then discovered a mode of glazing it to such perfection that centuries of weather do not in the least affect it. He then contrived to color it in the most beautiful manner; and all Florence, and every part of Italy, may be said to be filled with works of art equal to anything produced in marble, and valued as high. He went on improving his art; he began, then, tesselated pavements, and outsides of churches, which are most beautiful; and then, taking to himself, not a number of workmen to mold under him, but two near relatives of his, who were also artists and sculptors in marble, and who had left marble to come to work in clay, this family carried on the same work to the third generation, when the secret of the art expired with the family. But in those three generations, till Pope Leo gave the commission of making the pavement of the Loggie Raffaelle, this family made an infinite number of original works of art, executed by hand, colored and baked by themselves. Now, there is a whole family of artists, in whom the productive and artistic skill were united. In our estimation we should say what a descent that was for a sculptor in bronze and marble to come to a mere potter! But I will read to you Vasari's sentiments on that subject, who, as the great biographer of artists, and who lived among artists, and was himself an artist, may be allowed to have a right sentiment upon it. He says: "Luke therefore, passing from one sort of work to another, from marble to bronze, and from bronze to clay, did so, not from any idleness, nor from being, like many others, capricious, unstable, and discontented with his art, but because he felt himself drawn to new pursuits, and to an art requiring less labor and time, and rendering him more gain; hence the world and the arts of design became enriched with an art, new, useful, and most beautiful; and he, with glory and praise, immortal and unfailing."

We are told by Pliny that it was in the time of Augustus the prac-

tice was introduced of painting the walls of houses. Temples were undoubtedly painted before; because he tells us, that, when the temple of Ceres was falling into ruins, the paintings of Demophilus were cut away from the walls, (as is sometimes now done with frescoes,) and put into frames in order to preserve them. On one occasion, by the way, the city of Rhodes was saved, when Demetrius besieged it, because he feared a beautiful painting would be destroyed that was on the wall of one of the buildings. This painting of walls corresponded to our paper-hangings. What we do by putting on stained or colored paper, they did with the brush and the skill of the artist. The walls of Pompeii and Herculaneum are covered with most beautiful paintings, not merely ornamental patterns and arabesques, but there is such a mixture of the mere ornament, and of figures perfectly designed and colored, as to show that there was no distinction made then between the painter of a fresco and the house decorator; *the artist was himself the performer of the work*, and so beautiful is it, that we have hardly anything in modern times superior to what is commonly found on the walls of the private houses of cities which were in a province remote from the capital, and which had no particular recommendation, that we know of, as seats of art.

We have an instance, also, in modern times. Perhaps one of the most beautiful productions of modern art is the painting of that gallery to which I have alluded, where we see that *Raffaelle undertakes to do what now one would never think of committing to the hands of any one higher than a common house-decorator.* No nobleman, nor even a monarch, would think of asking the first artist of the kingdom to design the ornament of a gallery, scroll-work, and grotesques, or mechanical ornament, which now would be done by a common process or a common hand. But in a former age there was no distinction made between what we now consider the higher and the lower sorts of art; *but the whole of art was regarded as one thing;* the greatest of artists considered it was his place to make even the smallest work—which might be insignificant in itself—great and noble, and to stamp the highest impress of art on the commonest and most ordinary commissions that were given to him.

I will now speak of a department of art which will interest you, perhaps, more than others—art applied to textile fabrics. There is a great difference between what art can do in this department, and what it can do for those through which I have passed; because the others are in their nature more lasting; they are to continue for a time; they are worth, therefore, the attention and care of artists of the very highest class. The fashions of textile fabrics are perishable and fragile; they are capricious and changeable; therefore it is impossible to have the time, the leisure, and the same degree of labor expended on them as is necessary to produce a great work of art. I have read with considerable pleasure, and can bear testimony to the important suggestions in a pamphlet or lecture on this subject delivered in this city by Mr.

Potter. He is quite correct in his estimate of the somewhat exaggerated ideas which may exist of the power of art in connection with that which is not durable, and which, in reality, has its value, necessarily, for only a brief period. I agree, therefore, with him on that subject; but at the same time I accept as very important his concession that, even with regard to that degree of art which is compatible with the nature of the substance on which it is to be displayed, we do *not* do what we ought to do, and that we fall short of our neighbors, the French; or at least, that, while in that which is of secondary character we have put forth such perseverance and study as to have attained an equality with them, there is a point *in that which is more delicate and perfect* which we have not reached. This is an important concession. It appears there is some reason why, in France, they can produce, even in printed fabrics, a superior and more delicate artistic effect than can as yet be given here; and I shall have to speak of the reason of this, which accords completely with what I have said, because in these works, which are not made absolutely by handicraft, but with the assistance of mechanical skill, there *must* be a distinction between the designer and the mere workman—a man who keeps the machine in motion, and puts the work through it: although, no doubt, it is necessary for the designer also to have a considerable acquaintance with the process by which his design is to be brought out in actual manufacture. I only wish to observe how the principle comes down here. You know the cartoons at Hampton Court, the most perfect and finished work of art of Raffaelle. You would suppose these would be a labor of years, for they are all by his own hand, perhaps hardly aided by a disciple; and nothing can be more perfect than the outline and artistic distribution of the parts of the painting. What were these cartoons? Simply drawings for the loom. *Raffaelle did not think it below him to draw patterns which were to be sent to Holland or Belgium, and there to be executed in the loom by weavers of a carpet.* This shows how the very highest ideal art may bend without degradation to assist practical art with all its powers and resources; and where the union of the two in the same person cannot be got, then we have to think of the means by which the harmonious combination of both may be brought to produce one effect. While upon this subject, I am tempted to quote some beautiful lines upon the subject from one of our oldest but wisest poets; one who calls himself, upon his tomb, "the servant of Queen Elizabeth, the councilor of King James, and the friend of Sir Philip Sidney," Lord Brooke. Speaking as if it was considered in those days that the impulses of industry must be entirely regulated by the ruling power, he prescribes the duty of that in regard to the production of manufactures:

"To which end, power must nurseries erect,
And those trades cherish which use many hands;
Yet such as more by pains than skill effect,
And so by spirits more than vigor stand;
Whereby each creature may itself sustain,
And who excel, add honor to their gain."

Another remark I will read, which comes in the same passage, because it seems as, written in that age, prophetic of what may be considered the characteristic commercial policy of this day—that policy which particularly owes, if not its origin, certainly its greatest impulse, to this city of Manchester. He says:

"Now, though wise kings do by advantage play
With other states, by setting tax on toys,
Which, if needs do permit, they justly may,
As punishment for that vice which destroys,
To real things yet must they careful be,
Here and abroad, to keep them custom free;
Providing clothes and food no burden bear,
Then, equally distributing of trade,
So as no one rule what we eat or wear,
Or any town the gulf of all be made;
For, though from few wealth soon be had and known,
And still the rich kept servile by their own,
Yet no one city rich, or exchequer full,
Gives states such credit, strength, or reputation,
As that far-seeing, long-breathed wisdom will,
Which, by the well disposing of creation,
Breathes universal wealth, gives all content,
Is both the mine and scale of government."

Now, gentlemen, I wish to come to some general results. We have seen, that so far, in every instance we have examined, *wherever there has been real beauty and perfection of work, it has been in consequence of the practical art, and of the fine art, which ought to work together, being most closely combined, and, as nearly as it can be done, in the same individual*, or else in the most perfectly harmonious coöperation. Now, we must watch very carefully whether the plans which are being proposed for artistic education—to be applied to production—will tend to combine these two characters better, or further to separate them. I come to the conclusion, that if art has always flourished in its perfection when the two have been combined; and if, on the other hand, it is acknowledged that at present art is not applied to manufactures as it might be, and if it is, at the same time, the clearly visible fact that our artisans and workmen are not artists—I think I have a right to conclude that *this separation of the two characters is the cause of our inferiority, and that, therefore, the education which we are to prepare for those who are to carry productive art to its perfection must be one which will combine, closer than is now done, these two departments of what I consider one and the same thing*, Now, is it or can it be so by the education we are now giving? I observed that what I have said till now has been acknowledged long before by one of the greatest authorities in matters of art—that is, Dr. Waagen, the director of the Royal Gallery at Berlin. He was examined, in 1835, before a committee of the House of Commons on the improvement of arts and manufactures, and he said that "in former times artists were more workmen, and the

workmen were more artists, as in the time of Raffaelle; and it is very desirable to restore this happy connection." I was glad to find this corroboration of what I intended to say. He says again, "We have, then, to endeavor a connection between these two, the productive and beautiful art." Now, I ask what class of art was it which was in combination with productive art, to make it the parent of such a beautiful offspring in every department? *It was not low art;* it was not the mere knowing how to sketch an object from nature; it was not merely linear drawing; it was not merely elementary art: *but it was high art, and the highest art.* In every one of these cases the state of society was such—from what causes I do not undertake here to say—that it did permit the highest artists devoting themselves to what now they contemn and would despise; and, on the other hand, there was such honor given to the product of industry, that, when it really had the stamp of beauty upon it, it rose of itself to the department of high art.

Let me illustrate what I consider the danger to be guarded against by another example. When you go into a picture gallery now, and you see the portrait of a man, why do you care the least *who* that man was? You see the splendid effect; the countenance, which perhaps has not a beautiful feature in it, but which, by the noble expression, by the beautiful tone of color, by the majestic character thrown around the head, by the harmony between the parts, even by the accessories, is made so glorious that you can gaze upon it for hours. It may be a doge, it may be a merchant, a soldier, or a prince; you care not: you see there, not the portrait, but you see the painting by Titian, or by Rembrandt, or Vandyke; and the artistic merit so completely swallows up all the idea of personality of him who is represented, that, unless it happens to be some one particularly known, you never take the trouble of inquiring whom the painter represents. And why so? Because then portrait-painting had not become a distinct department of art. There was no such thing then as a person who called himself a portrait-painter, who thought he could produce a noble likeness of a man by merely giving a fac-simile of his features; but portraits were paintings by men who who could have painted an historical painting of the highest character, and to whom it would have been thought not unbecoming to commit the greatest artistic works imaginable. But in modern times the portrait-painter is an entirely different person, and the pictures produced by that class of artists are unfortunately of but little value except to those who have a personal interest in the subject of the portrait. You know, too, that every one of these portraits, which cover such a vast extent of the wall of the exhibition, will be transferred to the place of honor over the chimney-piece in the house of the owner; and, when his son grows up, it will be put on one side, that a portrait of the inheritor may take its place: and in the next generation it will be transferred to some other more out-of-the-way corner of the house, until at last it will find a more ignominious position than Cæsar's dust, stopping up a bunghole to keep

out the inclemency of the weather. From what does this come? *Simply from the attempt to divide art into parts*—to say that there shall be a class of men who can do a portrait, but who cannot do a historical or other great painting. And you find a difference when some of the great artists of the present day—for there are some truly great artists in England—do put their hands to what is considered another department of art, and paint the portrait of a friend, or of any one else; it becomes in itself a fine creation of art, and it will not perish when the person is forgotten; but it will be known by the name of the person who painted it, and not by the name of the person who sat for it. In this way, too, high art, when applied to a lower branch, *raises its character.* This is what ought to be the fundamental basis of artistic education. If we really mean to make more than improved designers or draughtsmen for mechanical work, we must have *great artists who are not afraid to work mechanically at the same time that they are great artists;* we must have the feeling that art commits no unworthy condescension in giving immediate assistance to the processes of production. The famous artists of whom I have been speaking were, as we have seen, men who worked at their business, and yet were not considered as working men; they were considered as artists, and treated as such. And it is that, I am afraid, which makes the great difference between our time and theirs. Art, unfortunately, is not now considered so noble as to give rank and station, as it did in those days. I do not mean that the great artists, those who devote themselves to what are considered works of high art, do not receive patronage and countenance, and even high honor; but we find that in those days such distinctions were bestowed on the artists themselves in productive toil. There is not, perhaps, any part of the history of art more interesting and beautiful than those portions of Cellini's memoirs which show us the manner in which he was treated; he used to go, when he pleased, to the pope to take him drawings and models; he speaks of going in without even waiting to be announced—going in the evening, after laboring all day in his workshop, as a matter of course. He was treated in the same manner by the grand duke of Tuscany, and by the king, Francis the First; when he was working for him, the king used to go at any hour and visit him; and Cellini gives rather a characteristic anecdote, proving how very familiar such visits were. One day, while at work, and, as usual, rather in ill temper, an apprentice or servant did something which displeased Cellini, and he roughly took the youth by the shoulders and pushed him across the room. The apprentice fell against the door, which was just then opened by the king, and he fell fairly into the king's arms. Such was the familiar way in which kings and great personages used to visit Cellini, and find him in his apron among his workmen. But I believe, myself, that it is not *patronage* which art wants in modern times. Patronage it has; you, gentlemen, here, many of you, I know, would not scruple to go far beyond the mere calculation of interest, were it in our power to raise, by your patronage,

any one who gave evidence of genius, and reward him as he deserved. It is not patronage, but honor, that art wants.

Now, speaking of the department to which I have just alluded, there is a passage worth quoting from Mr. Ward's book, "The World and its Workshop," on the difference between English and French designers in the textile fabrics. "France has studiously cultivated the art of design, and advanced its professors to the rank of gentlemen; in England, on the contrary, with some exception, it has been degraded to a mechanical employment, and remunerated at weekly wages. France has, in consequence, a species of industry to which we have no claim—the production of design for exportation." Now, having drawn these general conclusions, we must come to some practical applications. The first, that we must avoid making too great a separation between that character of art which it is proposed, now, to impart to our products and the higher departments of arts. I have observed that the separation of art into two departments, high and low, seems to be dangerous, and it will, perhaps, prove fatal. You may educate a great number of good designers, persons who will make tolerable drawings, and with rapidity; but the influence upon these which are considered the lower stages of art must come, not from below, but from above; it is only art in its highest department that gives the true feeling of proportion, the right sense of harmony, whether in color or in design, that gives also that sense and feeling of the adaption and propriety of things to their purpose, which is indispensable. Any one must be surprised at seeing the extraordinary combination of the styles of different countries and times in our works of art, from the want of a regular artistic education. I therefore think that the first thing which must be done is to try an education which will not give merely a great degree of elementary artistic power, but that, while we give what may be called the rudiments of art to every one, if possible, so as to give them all the opportunity of developing a higher taste and power, if they possess it, we must not, in looking beyond that, satisfy ourselves with the idea that we can educate a great number of artisans to a middling degree of artistic feeling, in the hope that thereby we may influence the character of our manufactures; but we must endeavor to combine the two, to bring down the high art to mingle with the lower, in the feeling that it is the common interest and duty of artists to improve the productive arts, *and to carry into actual work—not merely into design*—the powers which they possess.

The evidence of Mr. Skene, before the committee of the House of Commons, is to the same effect. He and Mr. Potter, and every other writer I have seen, agreed that we are not equal with the French in the more delicate operations of art applied to manufactures, and especially in textile fabrics; and he gives this reason: "The system of France is very different from that of this country, because in France artists of the first eminence employ their time—and make it a most profitable part

of their employment—in pattern-drawing, and they are paid very high prices by the manufacturers." This, then, accounts for everything, because it is the union of high art in design with manufacture that makes the French superior. The evidence of M. Coquerel, who is himself an eminent architect and designer, shows that a distinguished artist, who became president of the French Academy of Arts at Rome, and one of the first of his day, was employed at Sevres, in the china manufacture; and he states, also, that of fourteen or fifteen French artists of the first rank, educated at Rome, with whom he was acquainted, many were scattered through France assisting in the different manufactures. Finding the market for the highest class of artistic works so limited, and so full, these men, instead of sinking into despair or committing suicide, as has been seen in similar cases, turned their high talent to the assistance and improvement of manufactures; and they are not thought to have dishonored themselves by doing this; nor is it considered their superior education was thrown away upon them in qualifying them for the posts they now occupy. Why should it not be so here? Let any one go into the exhibition of paintings in London, and look around the walls; he will, perhaps, find only a small number of artists who can, with any hope of advancing themselves in the path to eminence, continue in what they may consider the highest department of art; and I cannot but think there are many in distress, persons who might be making an honorable livelihood, if they would apply their talents to what they would wrongly consider, perhaps, a degrading employment, but which is most honorable—the improvement of art in its productive department.

The second step which seems to me of the greatest importance, is to familiarize the people with art. This I know is a very trite topic, and one which can hardly be considered to require from us much attention. I know it is proposed to make museums in every part, and I think that excellent. But we must observe how it is that that familiarity with art has been obtained by other people; it has been, not so much by having places to which people were to go to see art, but by rendering it familiar everywhere to their eyes. The ancient Greeks, proceeding from other considerations, which we, as Christians, could not for a moment wish to have considered, such as the public spectacles, and feasts, and ceremonies of Greece, filled their whole country with works of art. Any one that will read the works of Pausanias, or the first book alone, will see how impossible it was for an Athenian to go ten yards in any direction in the city without seeing some beautiful work of art. On every side there were monuments, and statues, and temples, of the most beautiful workmanship and design; and the people became impregnated with the sense of artistic beauty; and therefore *whoever, even a mechanic, put his hand to any work, worked under the influence of that feeling.* In a later period, in Rome, there was the same plan of filling the public buildings, the streets and squares of the city, with sculptured monuments and with paintings

hung up so that the people could gaze on them; and Pliny gives us a long list of paintings put up by different emperors; and, by way of showing what was thought by the Romans of our northern ancestors, he says, that among those paintings on the walls of the Forum there was one of a shepherd; and when a German ambassador came to Rome, he was asked at what price would *he* value that picture?—which shows that it was considered by the Romans to be worth a high price, quite beyond a German's estimate; he, having so little idea of art that he did not consider that question applicable to any possible artistic merit, said, "Why, I would not have the man, if he were alive and breathing, if you would give him to me,"—he considering it was the value of the man, as a servant, and not of the picture, that he was to regard. In a later age, at Florence, Vasari tells us how he and Michael Angelo, and other artists, used to meet together, and then go from church to church to see the beautiful works of art in each, and then to discuss and criticise them. In the middle ages it was the *Church*, no doubt, which gave to public admiration the specimens of fine art, and kept them before the minds of all, and, in fact, made the people be artists. The consequence of this was, that, as Cellini tells us, when his statue of Perseus, after having been finished, was put into a public place, and when he uncovered it for the first time, "It so pleased God, that, as soon as ever my work was beheld by the populace, they set up so loud a shout of applause, that I began to be comforted for the mortifications I had undergone; and there were sonnets in my praise every day fastened up on the gate, and the very day I finished my work twenty more sonnets were set up, with the greatest praises of the work, and Latin and Greek poems were published on the occasion." So well had the Italian public learned how to appreciate a noble work of art!

Now, I look forward with no small expectation to what will be done by the new exhibition which is preparing, (this refers to the Manchester exhibition,) because I know that great pains have been taken to collect casts and copies of whatever is most beautiful in every department of art, beginning with the most remote period, down to the present time; and if it be really open to the public, and if, especially, it be open for some portion, at least, *of that day on which alone the artisan can enjoy it*, then I am sure it will do more toward raising the feeling of the people for art, and consequently toward introducing an improved practice, than any set of lessons or any teaching could do. A very strong remark is made by Dr. Waagen, before that committee, when asked if they shut up the museum at Berlin as they do in England, at certain times, to enable artists to copy; he says, "By no means, because I believe art is far more promoted by the people seeing it than it is by any number of artists making copies." But it appears to me *there has been a deficiency in the general education among us in the matter of artistic culture.* I cannot but be struck with this when I see that among all the colleges and schools belonging to this country, so respectable and richly endowed,

there is not one of them, so far as I know, which has made any collection or museum that might train the young men who are educated there in a familiarity with art. I do not think any college in either of our universities, Eton, or any of the schools, keeps before the eyes of its young men examples of painting, sculpture, and of other arts of design, which might accustom them during their early years to admire and appreciate art, and thus to contribute afterward their influence to elevate its character. At the same time, I must observe with sincere pleasure that this is not the case with our Catholic colleges; that, poor and unendowed as they are, there is not one of them which has not striven, at the same time while it has provided itself with a library, far beyond the proportion of its means, if compared with what others have done, to provide also some works of art, and keep them constantly before the students. At Stonyhurst there are many beautiful things, carving, lapidary, silver-work, and jewelry, especially for church purposes. Ushaw, or St. Cuthbert's College, near Durham, is another instance; the walls there are covered with paintings, many of excellent masters, and engravings of great beauty; there is a museum filled with specimens of art; the sacristy of the chapel is growing with proofs of the encouragement given there to modern artists, as well as with carefully-collected specimens of ancient art.

I may be allowed to revert also to the days which I spent in St. Mary's College, at Oscott. There, through the munificence of a departed nobleman, and under the guidance of the refined taste of the greatest artist of this day, because a practical disciple of all the arts—Mr. Pugin—there was collected a museum which would have been worthy of a larger establishment; beautiful specimens of carving, of enameling, and metal-work of every sort, so valuable that persons were sent from the department of practical art on purpose to make molds and copies of the specimens; and almost all the cloisters were covered with paintings, some by very respectable artists, and others good copies. The students were thus brought up in familiarity with choice objects of art, which has had an influence upon their lives since, and induced them to patronize and encourage art. That collection, moreover, was, in the most liberal way, thrown open to every one who chose to come and visit us; we never saw any feeling of narrow partisanship or exclusiveness of religious distinction; the house used to be visited every day by parties of people from the neighborhood; and nothing gave me greater pleasure than to see the young men who used to come there, and who were permitted to walk freely through the house. There was, at no great distance, a very considerable establishment for education, richly endowed, and having everything that could encourage the study of literature; but it did not possess, as it appeared, a single object of artistic interest within its walls; and often did the students of that establishment come up to St. Mary's and roam freely through it, and receive every courtesy. And *that* was at a time when Oscott was considered almost the center of a strong proselytizing tendency, *and I know that* personally *I* was much more engaged in contro-

versy then than I am at the present moment; and it was pleasing, therefore, to see that there was no feeling on the subject which could make it be apprehended as unpleasant for those young men to come to us. Bodies of those young men used to come to St. Mary's with letters from their principal, couched in the most courteous terms, asking, as a favor, that his students might be allowed to attend the establishment, which could have very little other merit to many than as it was filled with works of art; and on one occasion he informed me that, when any of the students of his house were particularly well-conducted, and had especially distinguished themselves, the best reward he could give them was to send them with a letter to us, to come and see Oscott College. Now, it will give you all pleasure to know that this generous, liberal, and gentlemanly-minded individual, the head of that neighboring college, was—the Rev. Prince Lee.

One thing more, I will observe, is important—that *we must not narrow the sphere of art. There is a tendency to do so in this practical scheme of education.* I observed in the late report, which may be considered as a programme of the department of practical art, that there are prizes proposed for artistic designs in three different departments—for printed garments, fabrics for carpets, and for paper-hangings. Now, one of the conditions of the four drawings to be sent in to compete for the prize in all three instances is this: "the designs to be flat, not imitative, but conventional, without relief, shadow, or perspective." Now, that is the mediæval principle, and cannot apply to other styles of art; *and you are narrowing the sphere of art if you dictate, as a necessary rule* of all designs in those three departments of productive art, that there shall not be relief or perspective in the painting; that the flowers must all be of one color, and that there must be no shadow, and no attempt to copy nature, but that the forms must be all "conventional," that is, such as a rose spread out into four parts, with a point between them, and the lily changed into a *fleur-de-lis*, and no natural forms to be truly imitated. Now, it is folly to think of competing with French art if our artisans are to be educated on that principle, because the beauty of design where nature is copied—where the flower glows in its own colors—will carry the taste of the public, and I think rightly, in preference to a series of flat and unshaped designs. I think it is a wrong principle; and why? Artists will tell you that the carpet is nothing more than a background for the furniture; that the hanging of a wall, paper or whatever it may be, is nothing but a background for the furniture; and therefore that these must be quiet and of a lower tint, with nothing brilliant, and no attempt at the representation of natural objects. *Now, I deny this principle;* they are not background. The papering of the wall is in the place of the ancient painting on the wall; and I do not see why, if you only avoid whatever may offend the eye—such as false perspective—there should not be all the beauty and glow of natural objects given to the pictured papering of the wall. If we are to collect museums, to put before our young artists specimens from the paintings of Pompeii, and

then to tell them that these wall paintings are done on a false principle, because they are good representations of natural objects, and not merely conventional drawings, how are we consistent? And if you tell a young man who designs patterns for carpets that there must be nothing there which would not be, naturally, in such a position—that there must be no sky or flowers there—then you go to make it a mere pavement and nothing better. I should say that the real carpet should take the place of the ancient mosaic. The ancients thought it not amiss to represent whole scenes on their pavement, with sky and rivers, men and horses; and Pliny tells us there were many celebrated men for this sort of work in Greece; but the most celebrated of all was Sosias; and he says among his other works at Pergamus there was a remarkable one which was called "The Unswept House." It was a representation which certainly does not give us a very good idea of cleanliness of domestic habits—of a floor on which all sorts of refuse had been left to lie about, fragments of meat, and the shells of crawfish, and everything which untidy people might leave after their meals. Such were the notions the ancients had of designs. I should, therefore, be inclined to fear that *if we began to deal with art upon a too confined basis*, and on principles which belong only to one period of the history of art, and if we now insist on their being made the sole basis of artistic education, *we shall produce cramped and narrow-minded artists*, and never enable them to take advantage of the great classical patterns to improve their taste.

In concluding, I think among the *greatest errors* that language has imposed upon us, there is none more remarkable than the sort of antagonism which is established in common language as between nature and art. We speak of art as being, in a certain manner, the rival of nature and opposed to it; we contrast them—we speak of the superiority of nature, and depreciate art as compared with it. On the other hand, *what is art but the effort that is made by human skill to seize upon the transitory features of nature, to give them the stamp of perpetuity?* If we study nature, we see that in her general laws she is unchangeable; the year goes on in its course, and day after day pass magnificently through the same revolutions. But there is not one single moment in which either nature, or anything that belongs to her, is stationary. The earth, the planets, and the sun and moon, are not for any instant in exactly the same relation mutually as they were in another instant. The face of nature is constantly changing; *and what is it that preserves that for us but art, which is not the rival, but the child, as well as the handmaid, of nature?* You find, when you watch the setting sun, how beautiful and how bright for an instant! then how it fades away! the sky and sea are covered with darkness, and the departed light is reflected, as it had been just now upon the water, still upon your mind. In that one evanescent moment a Claude or a Stanfield dips his pencil in the glowing sky, and transfers its hue to his canvas; and ages after, by the lamp of night, or in the brightness of the morning, we can contemplate that *evening scene of nature*, and again renew in ourselves all the emotions

which the reality could impart. And so it is with every other object. Each of us is, but for the present moment, the same as he is in this instant of his personal existence through which he is now passing. He is the child, the boy, the man, the aged one bending feebly over the last few steps of his career. You wish to possess him as he is now, in his youthful vigor, or in the maturity of his wisdom, and a Rembrandt, or a Titian, or a Herbert seizes that moment of grace, or of beauty, or of sage experience; and he stamps indelibly that loved image on his canvas; and for generations it is gazed on with admiration and with love. *We must not pretend a fight against nature, and say that we will make art different from what she is.* I will read you some beautiful lines, which show how our art must be derived from nature. I translate them from the excellent poem of Schiller, addressed to artists:

> The choicest blossom which the parterre warms,
> In one rich posy skillfully combined—
> *Such*, infant Art crept first from Nature's arms:
> Then are the posies in one wreath entwined.
> A second Art, in manlier bearing, stands,
> Fair work of man, created in his hands.

I believe the idea of these beautiful lines is taken from the anecdote which Pliny has preserved to us of the contest of art between Pausias the painter and Glycera the flower-girl; she used to combine her flowers with such exquisite beauty that they excited the admiration of the chief of artists, and he did not think it beneath his art to copy on the canvas the operation of her naturally-instructed fingers; and then she, in her turn, again would rival the picture, and produce a more beautiful bouquet still; and the painter, with his pencil, would again rival her, and produce by his art the same effect as she had done with the flowers of nature. *Let us therefore look on art but as the highest image that can be made of nature.* Consequently, while religion is the greatest and noblest mode in which we acknowledge the magnificent and all-wise majesty of God, and what he has done both for the spiritual and the physical existence of man, *let us look upon art as but the most graceful and natural tribute of homage we can pay to Him for the beauties which he has so lavishly scattered over creation.* Art, then, is to my mind, and I trust to you all, a sacred and a reverend thing, and one which must be treated with all nobleness of feeling and with all dignity of aim. We must not depress it; the education of our art must always be tending higher and higher; we must fear the possibility of our creating a mere lower class of artists which would degrade the higher departments, instead of endeavoring to blend and harmonize every department, so that *there shall cease to exist in the minds of men the distinction between high and low art.* I will conclude with another beautiful sentiment from the same poem:

> The bee may teach thee an industrious care;
> The worm, in skill, thy master thou must own;
> With higher spirits, *wisdom* thou dost share,
> But *Art*, O man! hast thou alone.

THE DIAMOND AND OTHER PRECIOUS STONES.

By M. Babinet, of the Institute of France.

Translated for the Smithsonian Institution

BY JOHN STEARNS, M. D.

The diamond, called by the Greeks "adamas," from its hardness and infrangibility, has attracted the attention of amateurs of precious stones from the most remote antiquity.

In regard to hardness, says Lucretius, diamonds are placed in the first rank, as they resist the blow of a hammer.

"Adamantina saxa
Prima acie constant, ictus contemnere sueta."

The second of these peculiarities is much more easily contested than the first; for notwithstanding all the fabulous assertions of ancient authors, the diamond, which scratches all other bodies and can be scratched by none, is easily broken by percussion, and is susceptible of *cleavage*, that is to say, of being readily divided by pressing steadily the sharp blade of a steel instrument in the direction of the natural seams of the stone.

When the rude Helvetians captured the treasures which were found in the tent of Charles the Bold, more sumptuous than those of the King, they divided with their hatchets some of the diamonds of this prince, to the great detriment of their value, as the entire stones were worth much more than the pieces into which they were divided. If we examine the many compilations from the ancients made at the time of the renaissance, we shall find a mass of undigested learning on the subject of gems. Notwithstanding the uncertainty of the names which he applies to many of the precious stones, Pliny is still highly esteemed as a compiler from ancient works now lost, and as an author of the first class. It was he who dared to undertake the composition of a history of nature analogous to what had been done before his time in regard to nations. The term *natural history* has become so familiar to us that the idea it conveyed, namely, a history of all things that contribute to make up a world, minerals, vegetables, and animals, has almost entirely lost the original magnitude of its signification. And in this connection it is worth while to pause for a moment to remark that science in its progress, as it has become more real and important, has gradually become more and more modest. Where, as with the Greeks, the word nature, *physis*, signified the generation or origin of beings, with us it is restricted to the system

century, gave many years of his life, and out of this study created a new science, one of the titles to glory of the human mind.

Pythagoras and Plato had without doubt given attention to crystallography, since in their schools they announced the marvelous proposition that nature, in the depths of her recesses, occupies herself with geometrical problems, and that God *geometrizes incessantly*,

Αει δεος γεωμετρει.

The old alchemists contended that the philosopher's stone could be produced from the commonest substance possible, and nature seems to have favored this idea in producing the most costly gems from the most worthless materials. She converts, as we have seen, a small quantity of black and friable carbon into a transparent diamond of a hardness and brilliancy unequaled. She takes a little of the glazing which the potter uses in his ordinary operations, and, coloring it with a trace of iron, produces a ruby or a sapphire. From a little worthless pebble, with slight additions, she forms the topaz, the emerald, and the amethyst. Some of the last-named gems have been reproduced in the furnaces of Sèvres in the same manner, without doubt, as nature has elaborated them, in her vast volcanic workshops, by those mysterious operations which have given to Vesuvius the title of the great crystal manufactory. Every one knows of the sarcasm with which Rousseau reproached the chemist Rouelle, demanding of him that he should produce corn from the chemical materials of which it was composed, rather than destroy that already made in its analysis. What would he say if he had seen the chemist produce carbon from the diamond, as readily as from a bit of wood or sugar, while he was powerless from the carbon to create the precious gem?

It might seem at first sight that those countries containing diamond mines, or mines of crystallized carbon, were the most favored; but this is far from being the case. The mines of Golconda, and of Visapour in India, of Brazil, of the Ural, and of Borneo, are not worth a moiety of those deposits of coal with which nature, a little parsimonious in regard to France, and still more so toward the vast territory of Russia, has endowed Belgium, England, and to an immense extent the United States.

By way of illustration, we can state that England, with all her wealth, does not import precious stones of a value greater than twelve or thirteen millions of francs, while her mines of coal yield a value of five hundred millions of francs per annum. How precious is this coal!

The diamond is commonly found imbedded in a sort of reddish cement. Sometimes the rock containing them requires to be broken, and often the sand at the base of torrents, or the earth which has received the waste of diamond-bearing rocks, is gathered, and submitted to frequent washings by machinery, to exclude the gravel and stones prior to the hand-washing which secures the gem.

Diamonds are always found covered by a rough coat, which is, in fact, the product of the chemical action of the crystalline formation. Nearly

all the other crystals, and especially those of quartz, are much more brilliant in their natural state. Had Socrates, who regarded the natural man as a block of marble, from which art can create a beautiful statue, known of the transformation created by the cutting of the rough diamond, he would certainly have preferred this comparison. The difference, however, in money value between the cut and the uncut diamond is not so great as might be supposed. For if the rough diamond loses half its weight by cutting, on the other hand, its value is doubled by the operation, without estimating the dust remaining, which has a value in the arts from its being employed in polishing many gems as well as the diamond itself.

The ancients do not appear to have had a suspicion that the diamond could be cut. They only knew it in its natural condition as a stone, having eight triangular surfaces, and in every direction presenting a double pyramid.

Louis de Berqueu, an artist of Bruges, about the middle of the fifteenth century, conceived the idea of cutting it at first by rubbing two diamonds, one against the other. If, in fact, we cement two diamonds on wooden handles, and rub point against point, we shall, little by little, grind them away, and obtain an artificial unpolished surface. To polish this surface we must use a circular plate of steel or of cast iron, like a grindstone, placed horizontally. But it is easy to see that if a diamond is merely placed against this grindstone, it would require a century to produce a polished surface. All that can be obtained by this process are grooves cut in the iron or steel. To effect the desired object, a happy thought suggested itself to Berqueu to sprinkle the surface, against which the diamond was rubbed, with diamond dust mixed with oil. The surface obtained in this way is regular, smooth, and perfectly polished. After the discovery that facets could be produced in the diamond, experience indicated in each case how a particular stone should be cut to produce the most advantageous effect.

There are two principal styles of cutting. The first is called the *brilliant*. In order to produce this style, the diamond to be cut must be pointed. If not naturally in this form, it must be reduced to it artificially. The points on the upper surface are ground down a little more than one-half, and those on the lower or under surface one-eighth. Then the light, entering through the larger upper surfaces, strikes the bottom surfaces, is reflected backward, traverses the side facets, is refracted, and produces prismatic effects. Every one knows what is the result when white light is decomposed into the colors of the rainbow, and coming to the eye, with every variety of hue, produces what is called the luster of the diamond. For this effect the light should not be voluminous, for there might be neutralization of these colors, and white light be reproduced. Nor should the facets be too large, for then the eye would receive all these colors at once, which would also reproduce white light.

The large diamonds, the Regent, belonging to the crown of France,

and the Koh-i-noor, belonging to that of England, are cut with facets too large, and not sufficiently numerous. It would have been better if the large upper surface, called the *table*, had been cut in a series of smaller facets, made to slope toward the edge, as is done for small colored stones.

The following is my method of studying the effect of a diamond: I pierce a hole in a white card a little larger than the diamond to be examined. Then passing a ray of sunlight or that of the electric lamp through this hole, I place the stone in the path of this ray, at a certain distance from the hole, behind the card, so that it shall receive the light on the table of its anterior surface. The rays reflected from the table, and also those which pass through into the diamond, are reflected back on the card, where they exhibit a white image of the table, surrounded by small bands iridescent with all the prismatic colors. Now, if the colors are considerable in number, well separated, and equally spread around the white reflection of the table, the diamond has been well cut. Each of the bands indicates one of the lusters of the stone, which may therefore be counted, and, consequently, in this way, the number, the quality, and the symmetry of the lusters can be determined; errors in cutting can be detected; and the form to produce the best effect can be ascertained. I have always intended to undertake by this method the study of the principal diamonds of France, but have always postponed it, being, like Homer, too much pressed with other work.

The second kind of cutting is called, for what reason I know not, the *rose*. It consists in leaving a large, smooth surface underneath, and in covering the upper surface with a great number of small facets, in order to produce on the face, by the reflection from below, lusters and colors similar to those of the brilliant. This cutting is used for stones of a flat form, the weight of which would be too much diminished in reducing them to the form of the brilliant. In this manner the great Indian diamond of England was originally cut, before it was presented to the Queen; in cutting it as a brilliant it has been reduced from 186 to about 103 carats. It is scarcely necessary to say that, by the process I have given, the rose-cutting can be as well verified as that of the brilliant. In both, large facets should be avoided even for the larger diamonds. As to the identity of the diamond known as the "Sancy," the name of one of the captains of Henry the Fourth, there is no agreement among connoisseurs. All the diamonds which pretend to this name weigh from 55 to 70 carats, and are cut in the form of a flattened pear, almost round, a shape called the *pendalogue*, having facets above and below, with a small, flat surface on the top. Several imitation diamonds cut in this style have given admirable effects, and I think that it should have been adopted in the cutting of both the crown diamond of England and the rough diamond, known as the *Star of the South*, presented to the Academy of Sciences by M. Dufrénoy. This kind of cutting, which I venture to call the *Sancy*, merits as much attention as those

known by the name of the *rose* or the *brilliant*. If from a single luminous point, multiplied by facets, we obtain several colored lights, it is evident that from a number of luminous points more splendid effects will be produced. For this reason the light from a number of wax candles or from uncovered jets of gas is more favorable to the brilliancy of the diamond than that from lamps or gas inclosed in globes of ground glass. Therefore those who sell diamonds would do well to remember that if in exhibiting them they substitute for the one or two large lamps frequently employed, candelabra containing a number of wax candles, the character of the gem will apparently at once be changed, and it will resemble in brilliancy that grouping known as the *parterre* or *basket of flowers*.

Whenever I have been invited to see an amateur collection, among which there was one princely diamond, (that is, above 10 carats weight,) I have often given the owner great and unexpected pleasure by lighting on a mantle-piece from eight to sixteen wax candles, thus calling forth, as it were, all the latent splendor of the gem. The reflection in the mantle-mirror doubles the number of candles; and if we turn our back to the mirror while holding the diamond in the hand, about the level of the eye, and vibrating it rapidly, the most beautiful effects are produced. If this secret had been known to Prince Potemkin, who enjoyed like a sybarite the company of his beautiful diamonds, he would have obtained a much higher pleasure from his favorite contemplation. In the splendid apartments of the Tuileries nothing is more easy to remark than the great difference between the brilliancy of these gems in the rooms lighted by wax candles compared with that obtained in those where gas-jets are inclosed in ground-glass globes. Walking, dancing, every movement of the body, however slight it may be, varies very perceptibly the ever changing play of the lights of this transcendently beautiful gem.

It is remarkable that the price of diamonds has remained invariable for several centuries. A perfect diamond, weighing one carat, is worth about 200 francs. Double this weight, and you quadruple the price, which is as the square of the weight, so that one weighing 10 carats would cost $10 \times 10 \times 200$, or 20,000 francs, which would be more than that of a first-class *solitaire*. Though it does not enter into our plan to speak of the arrangement of diamonds, and the best manner of setting them, which is properly the business of the jeweler, we will say that recently, admirable effects have been produced, at a great saving of cost, in substituting for one very large stone a diamond of more moderate dimensions, surrounded by eight brilliants of one carat each. Suppose we have for the middle stone of the necklace a diamond of four carats, worth 3,200 francs, surrounded by eight stones of one carat, worth 1,600 francs. We get for 4,800 francs an effect equal to that of a 10-carat diamond, which would cost from 20,000 to 25,000 francs.

The mines of India, at Golconda, Raolconde, Visapour, held for a long time the monopoly of the diamond market of the world. Of late,

however, Brazil has added its productions, which, having almost always a slight yellowish tint, contrast finely with the diamonds of India. It is from Brazil, at present, that nearly all the diamonds sold in Europe are obtained. These are first sent to Amsterdam to be cut, thence to Paris and London to be set, and thence they find their way through commerce to every part of the world. Borneo also furnishes a few hundred carats of diamonds. Humboldt conjectured that, from their formation, the Ural Mountains ought to produce diamonds, and research has justified his prediction. It does not appear, however, that these deposits have even yet been made productive in the way of regular mining. Algeria, also, has had the reputation of producing diamonds, and we have seen, in the possession of amateurs of mineralogy, specimens said to come from this locality; but whether these came from a real or supposed deposit, they have had no place in commerce, and the same may be said of the Californian and Australian diamonds. In general, the proportion of diamonds in circulation augments with that of the population that can afford to purchase them, which causes their price to remain nearly the same at all times. A panic due to the discovery of some new diamond beds in Brazil, about the year 1845, caused a temporary fall in the price of this gem, but the equilibrium was soon restored, and now, at London as at Paris, a diamond of one carat is worth the old price of 200 francs, more or less.

The number of stones which surpass in weight 100 carats is extremely limited. It is estimated that among 10,000 diamonds only one will be found weighing 10 carats, and consequently this will merit the name of *princely*. Russia, France, Tuscany, and England possess diamonds weighing over 100 carats. By far the chief among these, on account of its beauty, is the Regent, so called because it was to the Prince Regent that England owed its acquisition. All these large diamonds come from India. The Star of the South, of which we have just spoken, and which was shown to the Academy of Sciences January 3, 1856, came from Brazil, and was obtained from one of the new mines, the discovery of which caused the transitory depression of the diamond market. It was found in July, 1853, and weighed 254½ carats. This gem appeared perfectly limpid, and without that tint which has been the reproach of Brazilian diamonds. The cutting of it as a *brilliant* reduced it to half its original weight, which will make it about the same as that of the Regent, which is 136½ carats. To have cut it in the form which I call the *Sancy*, would have left it three-fourths of its original weight, and have given it a much more splendid luster. When I wished to suggest this the diamond had already been sent to Amsterdam. It was exhibited at Paris in the great exposition of 1856. It is estimated to weigh 127 carats. It is one of the five diamonds to which the name of *sovereigns* has been exclusively applied. Everything indicates that the number of these peerless minerals is extremely restricted, since so few have rewarded the arduous labor of searching for them.

If no more should ever be found, it will be on account of their extreme scarceness, which recalls a saying of Tacitus with regard to the pearls of England: "It is rather nature that fails in their production than the avidity of man in their discovery." Hitherto Borneo has contributed no diamond of any considerable size. It is true, however, that the almost impenetrable forests of this equatorial isle have prevented a thorough research. A late number of the Journal of the Geographical Society of London gives about 2,000 carats as the annual product of the mines of Borneo, which have never yet yielded a diamond of 36 carats. The monopoly of the government of Holland in this matter is found to be quite profitless, and it is probable that, as in Brazil, a considerable portion of the production is abstracted by contraband trade.

The rank of a diamond can only be approximately determined by its weight. If, for example, it is not of a beautiful water, perfectly pure, colorless, and limpid, it cannot receive the title of sovereign. Furthermore, if its luster is not brilliant, it will have to be recut to render it perfect, and in this operation it will lose weight. The Regent and the Koh-i-noor are equal in beauty, but the Regent of 136 carats is more valuable than its rival, which has been reduced in cutting from $186\frac{1}{16}$ carats to $102\frac{3}{16}$ carats. The diamond of Tuscany is of an inferior color, a yellowish lemon. The great diamond of Russia is rather ill-shaped; it is like a pigeon-egg cut in half, with facets over its whole contour. It is only a big stone, a species of heavy rose much too thick. If the Koh-i-noor and the Star of the South had been cut in the Sancy form, it is probable that with a brilliance equal to that of the Regent they would have surpassed it in weight. The Star of the South, when I saw it in the possession of M. Dufresnoy at the Institute, weighed $254\frac{1}{2}$ carats; but by injudicious cutting, I regret to say, it was reduced to 127 carats.

Permit me further to remark in regard to the Sancy form that it always admits of a subsequent cutting into that of the brilliant, and is easily experimented upon. For this reason it is prudent not to sacrifice until the last extremity so much weight as must be lost in reducing a stone of the form of the Indian or Brazil diamond by the ordinary cutting. I have seen at Amsterdam a model of the form which the latter would take by ordinary cutting. It will be like the Koh-i-noor, that is to say, not sufficiently thick for the size of its face.

In comparing the English diamond with the model of 100 carats given by Jeffries it will be found that its extent of face is almost double what it ought to be for a diamond properly cut.

It would be a curious speculation to follow the future history of the Star of the South after having shone at the French exposition. What name will this sovereign diamond assume? Will it be Albert or Francis Joseph? The proud Americans, sagacious estimaters of all commercial values, will they have the ambition to possess one of these rare productions of nature? "How have you managed to put so immense a price

on this pearl?" asked Philip II of an eastern merchant. "Sire, I knew there was in the world a King of Spain to buy it."

Thus far we have said little for science in this dissertation, and yet precious stones, and, in general, all crystals, from their geometrical forms, their chemical and mechanical properties, their weight, their color, their action on light, and their electrical qualities, they all offer the most delicate as well as interesting applications of the principles of physics. Haüy conceived a crystal to be made up of an assemblage of minute parts or molecules, each having the same definite form. From a few of these elementary molecules, which he called primary forms, he was enabled to build up all the forms which occur in nature, and in so doing he was led to inquire whether the same elementary forms might not give rise to more than one derivative form, or, in other words, whether the same substance could not crystallize in more than one form. Nature replied that she had anticipated his question by producing a specimen of the anticipated form. By the application of mathematical analysis to the fertile conception of Haüy all the forms of crystals which can possibly be produced by an aggregation of a given elementary form, as well as the forms which are incompatible with a particular elementary molecule, can be foretold, and these predictions are, in all cases, found to be in exact accord with the actual facts of observation; while the chemist and the mineralogist are continually adding to the list of crystals of theoretically possible forms, in no case has one been obtained of an *a priori* incompatible form.

Hardness is an important quality by which valuable stones are distinguished. In the cutting of the Koh-i-noor it was found that it required a whole day to produce facets which could be commonly formed in the course of three hours. It was also found necessary to increase the rapidity of the rotation of the wheel on which the diamond powder is spread. In an experiment made some years ago at the expense of the Institute, a black diamond of Borneo was put in the hands of Gallais, the diamond-cutter. On this he wore out a steel wheel and a large quantity of ordinary diamond powder without making the least impression on its surface. It lost none of its roughness, although loaded with a considerable weight, and heated almost to whiteness by the rubbing of the wheel, which revolved with such velocity as to emit a continual shower of sparks during the operation.

This intractable substance required the powder of black diamonds, like itself, to produce the desired effect, and doubtless some day the powder of black diamonds will be used to advantage in cutting the ordinary diamond as well as in other processes of the arts. Every one has seen a glazier, with a minute point of a diamond, trace upon glass an almost imperceptible groove in the crust of the glass, which renders it easily frangible in a given direction. It is conjectured by some that the ancients in engraving on sapphires and rubies have used a diamond point as a burin, and the finish of some parts of cameos and intaglios deeply

cut would appear to warrant this supposition. An art has been lost to France. Who will restore it? Since the last encouragements given to engraving on stone by the Empress Josephine and Napoleon I, everything of this kind comes to us from Italy, and there is not a single glyptic monument of the reigns which have succeeded the Empire.

The diamond is heavier than rock-crystal and lighter than white sapphire. It has almost the same weight as the white sapphire of Brazil, called *goutte d'eau*. It is often confounded with these three stones, which resemble it in whiteness. Let us see then how these may be distinguished by the weight.

It is known that if a real diamond be suspended by a fine thread from a delicate balance, and when in perfect equilibrium it be immersed in a glass of water placed immediately under it, it loses two-sevenths of its weight, or, in other words, two-sevenths of its weight in air must be added to the pan from which it is suspended to restore the equilibrium when the diamond is in the water. In like manner, a diamond weighing 21 carats loses in water about 6 centigrams. A white sapphire of the same weight loses only a fourth of its weight when weighed in water, that is to say, about 5 centigrams. A piece of rock-crystal in the same conditions loses 8 centigrams. Hence, whenever any species of crystal weighed in water loses more than two-sevenths of its actual weight, it cannot be a diamond. We shall presently see how the diamond is distinguished from the white topaz, which, like itself, loses in water two-sevenths of its weight.

Chemical tests being, in general, very difficult of application, and involving a loss of the substances examined, need not here be described; but we shall point out an optical test of a very delicate character which traces at once the line of demarkation between the diamond and all other colorless gems; we refer to that of double refraction.

In looking through a transparent stone at a detached object, such as the point of a needle, or a small hole pierced in a card, the object is seen double, as if there were two needle-points or two holes. This phenomenon is called double refraction, and is exhibited by all white or colorless gems except the diamond. As some little dexterity is required to readily exhibit this curious property, the object to be looked at and the stone should be fixed at the proper distance apart on a support by a little modeling-wax, so as to be more conveniently seen by those interested in the experiment. M. Haüy was often called upon in consultations of this kind, and sometimes, in the case of a suspected fraudulent sale, he gave his testimony in court as an expert in regard to the character of gems. The white topaz of Brazil produces double refraction, and may at once be recognized by this quality as a false diamond. I have a painful recollection of a visit from an English gentleman, who brought for my examination a magnificent white topaz, which, had it been diamond, would have been of immense value. It was very easy for me, from the cutting of the stone, to perceive the double refraction; but

such was the agitation of the owner, and so convulsively did his hand tremble, that I was obliged to attach the stone to a wooden ruler with a bit of green wax before I could render the phenomenon clear to him. The instant he saw the double refraction, the bearing of which I had explained, he seemed overcome with emotion; and after remaining some minutes in a half-stupefied condition, he suddenly rose and abruptly took his leave, doubtless to hide his emotion, too powerful to be controlled. He afterward sent me his card, apologizing for his hasty departure, but I never learned what great interest I had compromised or what hopes I had dissipated in thus determining the character of the stone. In the work of Mawe, it may be seen that the white sapphire and the white diamond owe their high price to the fact that they are often fraudulently substituted for diamonds. Mawe might have added, also, the white zircon, which is heavier even than the sapphire, and which much more resembles the diamond. To exhibit one of these stones in dress as a real diamond may be only a small exhibition of vanity, but to sell one for a diamond is a felony which, fortunately, is recognized as such by our courts of justice.

I need scarcely add that the zircon, like the white sapphire and topaz, possesses the quality of double refraction in a high degree. The test of double refraction is a very convenient one, because it can be exercised without unsetting the stone, and without any complicated apparatus. A little practice enables any one very soon to learn how to recognize the phenomenon; and this is not much to pay for gaining so absolute a means of identifying a false diamond.

Diamonds are capable of being colored in various ways. A slight tinge, as in the case of the great Tuscany and the Russian diamonds, detracts from the value; but when a diamond is found of a lively and rich color, it is very much sought after as a very rare specimen. The Marquis of Drée possesses several of this kind, and especially one of fine rose tint. The specimens which have this character are called *stones of affection*, and really their owners sometimes regard them with a sentiment which fully justifies the name. Among the crown diamonds of France there was one of triangular shape, of a fine sapphire blue, and weighing 60 carats. This disappeared at the time of the theft of these diamonds, none of which, except the *Regent*, were ever recovered, doubtless because this latter was of more difficult sale than the rest. During his imprisonment, the thief enjoyed among his companions great consideration on account of the magnitude of his villainy. On what may not distinction be based in this world?

But the wonder of all colored diamonds is the blue one, owned by Mr. Hope, the form of which has been engraved in the report of the London Exposition. Mawe characterizes it as *superlatively beautiful*. It weighs 44¼ carats, and often, according to Mr. Tennant, unites the blue color of the sapphire with the prismatic luster and brilliance of the diamond. Every one who has studied the play and the effect of precious stones in

any brilliant evening assembly has remarked that the sapphire, sparkling as it may be by day, becomes dull and lusterless in the light of lamps, wax candles, or gas. It would be curious to know whether the same loss of brilliance happens to the blue diamond of Mr. Hope, which I do not hesitate to place beside the sovereigns in value, because, though less heavy than they, it surpasses them in rarity. The term *stone of affection* is scarcely an inappropriate name for this precious object, though it is sometimes applied with more questionable propriety. I once saw a stone at M. Bapst's, known as a *black diamond*, which had the color of a tobacco-leaf, and was only admirable on account of its singularity. Louis XVIII, however, selected it for the crown of France, at 24,000 francs, but it was never placed there. Such diamonds are always cut very thin; for what is the use of thickness in a stone which is not transparent, and of which the superficial brilliance is quite vivid? If to an amateur such a stone should become one *of affection*, he certainly would run no risk of having his taste disputed. It is curious to remark that Pliny says almost the same thing of Nonius, who, owning a beautiful opal, preferred to quit Rome as a proscribed traitor, rather than yield to Antony his *stone of affection*. "It was," says Pliny, "an astonishing instance of tyranny on the part of Antony to proscribe a citizen for the sake of a gem; but we can none the less wonder at the obstinacy of Nonius, who, rather than give up his beloved opal, suffered himself to be exiled from his country. In reading the interminable list of marvelous qualities attributed before the seventeenth century to gems, we may understand something of the extreme value set by the possessors of precious stones on these treasures. The native Indian princes are great amateurs of diamonds, and seek for them with great assiduity. In one of their collections I have seen a small natural diamond, with brilliant points, encased in the red cement which ordinarily envelopes the stone in the mine. This specimen, which was about the size of a small hazelnut, and in which the little diamond was enshrined within the cement, formed an object well adapted to excite the wonder and admiration of the mineralogist, as well as the superstitious regard of the princely, though unscientific, owner.

Mawe states that of all values the least variable is that of the diamond. He cites various crises which have occurred in England in the quantity of diamonds received, and shows that, with regard to price, these crises have been generally very light and of short duration. There have been two great panics in the diamond market since 1840. The first was on the discovery of the new mines in Brazil, about 1843 or 1844. The second was in France, and followed the commercial shock caused by the revolution of 1848. The price of diamonds then rose and fell with other securities, and in precisely the same proportions. The price is now about 200 francs the carat, a price indicated by Jeffries reaching to about 250 francs. M. Castelnau, in his Voyage across South America, hints that the fall in the price of diamonds came from a diminution in the taste of society

for these brilliant and other frivolous decorations. If the depreciation in the value of diamonds is to depend on a decline in the taste for luxury and ostentation, a desire to shine, and even on the cupidity of man, a rich commerce in these gems may be assured in London and Paris for many centuries to come.

Without recurring to the *Arabian Nights*, or to the legends of the middle ages, where gnomes and griffins are seen jealously guarding these treasures of the earth, and only by the force of some cabal allowing mortals to obtain them, it is evident that a great value assigned to a small quantity of mineral substance has given rise to singular changes in fortune. I do not know on what foundation Mawe says that Liégés, embassador to the court of Berlin, obtained from the King of Prussia a treaty of alliance, offensive and defensive, by dazzling his eyes with the splendor of the *Regent*, for the cession of which by France the abbé allowed the King to entertain a hope. Frequently the precious stones of sovereigns have been used as pledges for the payment of debts; but these transactions are comparatively of little interest, and we prefer much more to contemplate the incident of a poor gardener of Golconda finding in his garden a beautiful stone, which proving to be a diamond, afforded, not only ease and comfort to himself and his family, but opened to his whole country a source of riches. We also prefer to dwell on the fortune of a poor negress who found the Star of the South, in July, 1853, while washing the sands of the Brazilian mine of Bagagen. According to the ancients, Hercules presided over the discovery of treasures. By this perhaps they wished to indicate that what is truly valuable can only be attained by untiring industry. But be this as it may, the discovery of a gem was never considered by them as a favor from Hercules, but as the reward of labor.

An anecdote of notable fidelity is connected with the *Sancy*, which is worthy of repetition. This gem was bought at Constantinople during an embassy, by a baron of the name of Sancy, for 600,000 livres. During the many years in which Henry IV, after the death of his predecessor, was rather an appendage to the throne than King in reality, several of his barons rendered him pecuniary assistance, and, among others, the Baron of Sancy, who placed the diamond bearing his name in charge of a domestic, to be delivered to the King. In the brigandism which then desolated France, this servant was attacked and assassinated. For a long time his master knew not what had become of him; but after much searching it was discovered that he had been killed in a certain rural commune, and that his body was interred in the cemetery belonging to the locality. When condolences on this discovery were tendered to the baron on the loss of his splendid jewel, he replied, "You are very much in error, gentlemen; since I now know where to find the body of my servant, I know, also, where to find my diamond." In fact, when the body was disinterred the diamond was found; it had been swallowed by the man to secure it from his assailants.

I may in this connection also recite an incident coming within my personal knowledge. I had intrusted a diamond of considerable value to a young trader to be recut in Amsterdam. He there, however, met with reverses, and returned to Paris in a state of the greatest destitution. During the last days of his homeward travel he was obliged to live upon the wild fruits of the earth, and to sleep in the open air. Although I found him on his return in an apartment with bare walls, and his couch a bed of straw, he had been faithful to his trust. He handed me my jewel, apparently unconscious of merit, merely claiming from me the price of the recutting. After this sad epoch, fortune smiled upon him, and in his prosperity I fancy that I see a providential recompense of such rectitude amid unusual temptation.

The art of making diamonds has been almost as eagerly sought as that of producing gold. The problems are not, however, the same in principle, since to make a diamond is simply to crystallize carbon or charcoal; while in producing gold the alchymists attempted to change the very nature of bodies, and to make gold of all things. Modern chemistry having burnt the diamond, and discovered that the product of its combustion is the same as that obtained by the burning of charcoal, we would suppose that some peculiar compound of charcoal might be found which, submitted to such process as would allow the carbon to separate very slowly in a condition of perfect stillness, would produce regular crystalline forms.

It is thus that sugar, salt, and alum are deposited when the water which held them in solution is evaporated very slowly and in perfect stillness. Looking at it in this light, there is a curious substance which renders the experiment of diamond-making a hopeful matter. It is not generally known that in combining sulphur and carbon a colorless liquid is produced resembling water, and containing really nothing but sulphur and carbon. If by some process the sulphur could be got rid of, either wholly or partially, we might expect to see the carbon deposited in the crystalline state. So far this hope has failed. Many other plans have also failed, so that at this day the crystallization of charcoal is by most persons a thing despaired of. Despretz, a member of the Institute, was however, of a different opinion. By means of the voltaic battery he has obtained on a thread of platina small crystalline depositions, which, by their form and hardness, seem to be really embryonic diamonds. These crystals, or rather, let us say, these particles of diamond dust, have been used in polishing hard stones, in the same manner as ordinary diamond powder. The scientific question is then resolved. But this ingenious and sagacious academician did not stop here. He organized, as we may say, hundreds of preparations to facilitate the precipitation and aid crystallization of charcoal under the influence of electricity, an agent which in the researches of men is the obedient servant of his will. These interesting facts lead us to indulge the hope that persevering and sagacious labor will be rewarded by success in the crystallization of carbon.

and the manufacture of the diamond. Although this result might not be advantageous to commerce, it would be so to science. Nowhere does nature show us the diamond in the locality where it has been formed; it is now only obtained from ground which has changed its place, so that we get no light on the primitive conditions of its crystallization, a circumstance which seems to confirm the views of Despretz, which is, that in Brazil, side by side with the diamond, there occurs a curious substance as hard as the diamond, which is called by the Portuguese *carbonado*, and in trade at Paris *carbone*. Speaking of the mines of Brazil, Tennant says of it: "There is found here a considerable quantity of a black substance of the same specific gravity as the diamond, laminated or rather composed of a succession of laminella generally broken into separate fragments. It is too imperfectly crystallized to be cut; though it possesses in places the brilliance of the diamond, and can be reduced to powder for the polishing of other stones. Its name, *carbonado*, is due to its having an appearance resembling charcoal. May not this be the same substance as that artificially obtained by Despretz? In the age of Louis XIV, it was thought that it was quite possible to increase the size of diamonds by placing them in certain solutions, just as a piece of salt may be increased in size by placing it in a solution of the same substance. Despretz has, doubtless, considered the property that a crystal possesses of attracting and regularly arranging around itself particles of matter analogous to its own. At present this is the whole scientific condition of the subject. Let us wait for future developments.

Several years ago the premature announcement of the artificial production of diamonds agitated all Paris. Baron Thenard, however, by an experimental examination reassured the many merchants and families who had been alarmed on account of the threatened depreciation of their fortunes, based on the value of this queen of gems. Since this time the number of diamonds has increased in France, and is every day increasing, even more rapidly than in England, and now represents an immense capital. According to the remark of Achard, there is no article which being resold, suffers so little loss, so little depreciation, while at the same time it is always in demand. It may almost be considered a circulating medium for high values. Furthermore, in the actual state of physics and chemistry, nothing warrants the fear that the artificial will ever compete with the natural product. The case is analogous to the well-known production of the gold pieces made by M. Sage, from gold extracted from the ashes of certain burned vegetable substances, a beautiful scientific result, but by no means lucrative, since every piece of twenty francs cost 125 francs in the making.

In like manner, we may say that if the process were known, the artificial gem would cost more than its worth.

The other precious stones have been designated "colored gems." In fact, their principal merit is the beauty of color and play of light which distinguishes them, but to this we may add hardness, which insures their

preservation, and which is one of the most important qualities that a precious stone can possess. Pliny says that in gems we see all the majesty of nature united in a small space, and that in no other of her works does she present anything more admirable. According to him, the first one who wore a precious stone was the Titan Prometheus. Released from his bonds and impressed by some ideal sentiment, he inserted in a piece of his chain a fragment of the rock to which he had been fastened, and thus formed a ring, which he ever after wore in memory of his misfortunes. Is there not some allegorical sense in this story of the construction of the first ring? What leads us to this supposition is the mysterious personage himself who is made the wearer. This grand personage Prometheus, the benefactor of man, who gave him fire stolen from the gods, has always been venerated in antiquity for his opposition to the imperious domination of Jupiter.

The ancients included also, under the name of gems, stones engraven either in relief or in intaglio, and in this form of art they have left us the most admirable productions that the imagination can conceive. Here, as in sculpture, the moderns have neither surpassed nor even attained to the perfection of the works of antiquity. Engraven stones, which were used as seals, are now the most precious and valuable of relics, while they afford us definite mineralogical ideas as to the various kinds of ornamental stones known from the earliest period of history.

Stones of color do not probably, at the present day, represent more than one-tenth of the total value of gems, while diamonds may be estimated as ninety per cent. This was different among the ancients. With them the diamond was hardly known as an ornamental jewel, because it was uncut, and did not exhibit those vivid colors which now place it in the highest rank among precious stones. Furthermore, our system of lighting with lamps, gas, or candles, throws upon all objects tints very unfavorable to the natural color of gems. Thus the garnet, turquoise, amethyst, and even the opal, lose much of their luster in these artificial lights. When a colored stone is placed in the path of the solar spectrum, its color will vary with the portion of the spectrum which falls upon it; and two stones of the same color, but of a different nature, will exhibit different effects. Thus a paste, placed beside a fine colored stone, betrays its worthlessness. A simpler method of testing stones is to look at them through a bit of glass colored red, yellow, blue, or green. Every stone will exhibit under this test properties peculiar to itself, and by which its nature may be recognized.

Since we have spoken of paste, I would remark that in spite of the high price of fine stones, there are fewer false ones used than at first we should be inclined to believe. Paste, colored or not, is only a very fine glass overcharged with lead and enamel, analogous to the best quality of cut-glass for table service. In the early times of its substitution for precious stones, it was cut very carefully; now it has become common and cheap and inferior in workmanship. Besides, national

riches augmenting from day to day, and the insufficiency of paste for beauty and duration becoming more and more apparent, a greater expense for something of imperishable value is preferred to a less price paid for what is really an article of no permanent worth. We are now long past the time when the Duchess of Berri, arriving in France, received for her bridal ornaments only paste, and when, in order to make the Duke of Wellington a present in diamonds of less than a million francs in value, the Paris trade was obliged to borrow from the civil list a certain number, guaranteeing their restitution in kind.

Before speaking further of colored stones, a question presents itself: Can science explain the coloring of these gems? There are, I suppose, few persons who do not know that the white light which reaches us from the sun and other heavenly bodies can be decomposed into a number of colored rays. Thus, when the light of the sun passes through a triangular prism, it is bent, and will trace on a white card placed opposite to it an iridescent band, in which Newton has marked seven colors, according to some idea of analogy with the seven notes of a musical octave; an idea which is, after all, without foundation, since every prism gives its own peculiar band. The idea was by no means new. The Greeks and Romans entertained it, and Nero, who in dying pitied the world for losing so great an artist as himself, has sung it in verse. A child blowing a soap-bubble produces colors as splendid. In a word, every thin plate of any transparent substance whatever becomes colored under white light. Striated surfaces also offer effects not less brilliant: so that, to clothe certain insects more vividly, nature has grooved the tissue that envelopes them. The globules of clouds between us and the moon produce also, with white light, the most vivid colors; and, above all in beauty, the *iris* or rainbow, which the sun paints in a thousand colors in the drops of the falling shower, is the transcendent effect of decomposed light. Nature always, with a palette, so to speak, charged only with white, knows the art of spreading over all her pictures the magic and glow of the most brilliant coloring. But we have not exhausted all the resources of this coloring, the secret of which is the light itself. How shall we explain the whiteness of the snow, which covers our planet at either pole, and on the summits of the loftiest mountains? How account for the perpetual greenness of countries covered with plants and trees, the blue of the vast aerial sea which envelopes the earth, or the color of the great ocean which rests on its surface? Here science is in default. The cause of the color proper to bodies is only half perceived: and we can say still that which Huyghens said at the end of the seventeenth century, "In spite of the labors of Newton, no one has yet fully discovered the cause of the color of bodies." We must then admire, without penetrating their secret, the unparalleled red of the oriental ruby, the pure yellow of the topaz, the unmingled greenness of the emerald, the soft blue of the sapphire, and the rich violet of the amethyst. This is not the only thing the discovery of which we shall leave to posterity.

In the enumeration that follows we shall place the precious stones in the order of their actual value. This order varies little in different parts of the world. When an extraordinary demand, however, occurs, that causes a rise in price of any particular gem, there flows into the market such an overplus of that gem, that a fall in value is at once effected. This is the case at present with the beautiful Hungarian opal, which in the last ten years has become abundant, the mines producing it being more actively worked on account of the high price of these stones, which for a while has surpassed that of the sapphire. The oriental *ruby* is, for its price as well as its beauty, the first in rank among colored stones. In order to appreciate its color in its finest quality we must compare it with the blood as it spirts from an artery, or the red ray in the solar spectrum. It is the pure red on the painter's palette, without any admixture on the one side of orange, or on the other of violet. Many of the stained-glass windows in our ancient churches, when traversed by the rays of light, give this color in its brilliance. The ruby is excessively hard, and, after the sapphire, which surpasses it a little in this respect, is the first of stones, always excepting the diamond, to which there is nothing at all comparable. According to a perfectly just remark of M. Charles Achard, more competent than any one in France to give an opinion touching the trade in colored stones, there is a great difference between these and the diamond, which, from the minutest specimens to those of princely or sovereign size, have a fixed price proportioned to their weight, as is the case with gold and silver. As for rubies and other gems, the very small specimens have hardly any value, and it is only when of some weight that they command high prices. Rubies are, therefore, much used for watch-pivots, and, from their abundance, are of little value; but for a ruby of 5 carats, double the price of a diamond of the same weight will be paid. If the ruby weighs 10 carats, triple the value of a diamond of the same weight may be asked for it; which price would be about 20,000 to 25,000 francs. All the world admits that a perfect ruby is the rarest of all the productions of nature. Its tint shows to the same advantage by day as by lamp light; but to render the color more resplendent it should be placed in the midst of the red rays of the spectrum in such a manner that the rest of the colors do not fall very near it. The possessors of choice collections of stones can repeat this interesting experiment with various stones, placing each in that color of the spectrum which is analogous to that of the stone itself. It is a severe test for the purity of the tint; for if pure and unmixed, the stone will appear completely black in every other light but its own. Milky and turbid stones cannot bear this test.

When Pegu was annexed to the British East India Possessions, it was thought that that country, so rich in rubies, would send many of these stones, so jealously guarded by the Indian princes, into the European market. Such has not been the case. It is not yet proven, however, that the ruby mines are still worked; and this part of Asia is the least

known of all the countries of the globe. Merchants in rubies will never cease expatiation on the number of tigers, lions, elephants, and venomous serpents which people the forests and the plains of this country, which, according to them, is only accessible by the openings of the rivers from the sea. The actual state of the island of Borneo, as authentically given, seems very much to confirm these rather interested accounts. I do not know that the rajahs attach a superstitious importance to the possession of rubies, but it is certain that they never sell any of considerable weight. With the *Koh-i-noor*, Runjeet Singh possessed a no less precious ruby, which was of the shape of the large end of an egg that had been cut in two. This enormous gem made a part of the necklace of this prince, and was estimated by him, without any fear of finding a purchaser, at 12,500,000 pounds sterling—about as much as 300,000,000 francs. We know nothing of the quality or weight of this ruby, which has not yet been brought to England. The ruby is, with the sapphire, the zircon, and the garnet, one of the heaviest of stones. In water it loses only about the fourth of its weight.

The Indian princes set their beautiful rubies in the collet of a ring, somewhat elevated, and surround them by several rows of small diamonds, so that the whole produces a kind of disproportionate elevation, contrary to our ideas of good taste, which admits but a single stone in a simple French setting, the stone not too prominent—for example, in diamonds, a solitaire of three or four carats.

The composition of rubies is no less extraordinary than that of the diamond. Like the sapphire, the ruby is nothing more than a bit of crystallized earth, colored by iron, which naturalists call the painter of nature. It is not too much to repeat the strange assertion, that nature has made the most precious stones with the most common materials, we will say that this kind of earth, called *aluminium* or clay, and the white pebble or rock-crystal, called *silica*, or flint, form the base of nearly all gems. Opal is rock-crystal with water. Topaz joins a little fluoric acid to silex and aluminium. The emerald, the crysolite, the aqua-marine, the tourmaline, and the eulase contain another element besides silex and aluminium, viz: *glucine*. Finally, garnet is so ferruginous that it acts on the magnetic needle. The zircon, a stone very little esteemed in France, has for base a peculiar kind of earth called *zircone*.

As accessory to the ruby, we may mention a stone less deeply red in color, called the *spinelle ruby*. The crystalline form of this differs from that of the oriental ruby, which is a six-sided cylinder, cut squarely at both ends; while the spinelle is, like the diamond, a double pyramid. The name of *balass ruby* has been given to a stone of Magal, which several authors regard as a real oriental ruby, only having a less rich color. The ancients did not apply the name ruby to this stone. It is called by Pliny *carbuncule*, (incandescent coal,) and by Ovid and the poets *pyrope*, or that which has the color of fire—

Flammas imitante pyrope.

With us the word carbuncle is little used except to describe a ruby of considerable size. Pliny has evidently confounded the Indian ruby with the garnet, which is found everywhere. Certain rubies cut spherically—a form which is called *calotte sphérique*, tallow drop, or *cabochon*—present in the middle of their red tint a white six-rayed star, which changes with the position of the eye and forms in the sunlight a beautiful spectacle. This effect is called *astérie*. It is found also in the sapphire, a near relation of the ruby; like it, being composed of aluminium, and colored by iron, differing only in its color, which is blue, while that of the ruby is the most vivid and purest red.

Next in rank to the ruby we place the *emerald*, of which Pliny says no gem has a color so agreeable. This stone, which comes to us from Peru and New Grenada, is very soft, hardly scratching rock-crystal. It is found in beautiful green crystals, implanted and produced in a kind of freestone of a whitish color; and we can comprehend no cause other than electricity for such a deposit as that of the emerald in the midst of a stone differing both in nature and in color from this gem. Nero, who was near-sighted, used an emerald, hollowed on both sides, through which to look at the games in the amphitheaters. This was doubtless the first approach to spectacles, since this invention does not date very far back.

The emerald, like the ruby, is a six-sided prism and squarely cut at the ends. This stone is very light, losing in water more than one-third of its weight. Its tint is so lovely that we overlook its want of hardness, which might properly almost exclude it from the rank of distinguished gems. At the time of the conquest of Peru a magnificent emerald was sent in homage to the Pope; and several years afterward the emerald mines there were said to be exhausted or lost. About twenty years ago the principal of a large establishment in Paris, M. Mention, received from South America some magnificent specimens, which quite revived the emerald trade, continued since without interruption by Charles Achard. The deeper the hue of the emerald the more it is esteemed. It is the largest end of the crystal that is the most strongly colored. The emerald loses none of its brilliance in artificial light; a valuable property in our modern society, where all great reunions are held at night. Haüy includes in the emerald family the aqua-marine and the beryl, one of a greenish blue, the other yellow, but both being like the emerald in form and chemical composition.

The emerald, as well as all stones whose color we wish to develop, should be cut with a flat upper surface, surrounded by retreating facets, continued all the way underneath. The orientals cut them in broad thin plates, which, apparently, ought to show the colors of the stone to the best advantage; but the reflection of white light from the large upper surface becoming mingled with that which traverses the gem, renders the hues of the latter less discernible. This is the reason why they are not cut with a table and surrounded by facets; for thus in

avoiding a large reflecting upper surface, the stone is made to exhibit its fundamental color throughout its whole extent. The emerald, though much cheaper than the beautiful ruby, is nevertheless much admired and sought for. We might almost call it a "stone of general affection," so much is it esteemed by the many.

The *sapphire*, which comes after the emerald, is the hardest of colored stones. It may be considered as a blue ruby, or the ruby as a red sapphire. With Haüy and Mawe, we can say that aluminium is susceptible of crystallizing in almost all colors. The mineralogical species to which the sapphire belongs is called the *corindon*. After the red *corindon*, or *oriental ruby*, comes the blue *corindon*, or *oriental sapphire*. Sometimes the *corindon* is of a beautiful yellow color; then it is called *oriental topaz*. More rarely it is of a violet hue; then it takes the name of *oriental amethyst*. Finally, it may be perfectly colorless, like rock-crystal, when it greatly resembles the diamond, with which it is sometimes confounded, but by its greater weight and its double refraction it may be easily distinguished.

By the microscope there may be discovered, in certain pale sapphires, traces in the direction of the faces of six-sided prisms. The light reflected by these internal filaments produces three small brilliant traces transversely to the filaments and to the faces of the prism. The crossing of these little bright lines forms within the stone a six-pointed star, which gives to the stone the name of *starry sapphire*. Among the orientals these stones are highly esteemed, especially when they exhibit the star in a ground of deep blue. Corindons of all colors are susceptible of being thus marked. In his voyages in Africa, M. Abbadie wore a blue starry sapphire, which often commanded the respect of the natives. There are stars on a red, blue, or yellow ground, according to the color of the corindon. As yet, this phenomenon has never been seen in the white sapphire. I have just said that this reflection arises from little filaments within the stone. These may result either from some foreign substance or from minute hollows left by the regular disposition of the particles at the moment of crystallization. If, instead of trying to observe these starry appearances by reflection, the stone is cut so that it can be looked through, then the phenomenon can be easily seen. Unless the stone is of a very perfect crystallization, the observer who takes for the point of sight a lighted candle, placed at a moderate distance, will perceive these little luminous lines of light crossing all the series of filaments which the mineral contains. According as the stone has a four or six sided form, we have a four or six rayed star, and if the filaments are all in one direction we have a luminous band.

In scratching with the point of a diamond a plate of glass in various directions, we produce bands of light of the same number as the traces upon the surface, which are always in a transverse direction to these traces. We can even very simply produce a star in spreading with the finger a little wax or grease upon a plate of thin glass. It is necessary

for this that the coating should be very thin so as merely to dull the glass, and that the finger should be moved directly across—for example, from right to left, or from above downward; then looking through it at a lighted candle, there will be seen a band of white light crossing the direction of the lines of tarnishing. If the same operation is performed in two directions on opposite sides of the glass, then a four-limbed cross will be formed by the two luminous bands which cross each other before the eye.

Ceylon produces a greenish stone traversed by filaments of white amianthus, which is called the *cat's-eye*, and which is usually cut spherically and quite prominent. We see in it a floating band, which comes from the play of light on the lines of amianthus within it. In general with these curious accidents of light exhibited by exceptional stones, the color of the starry radiance should contrast as much as possible with the tone of the stone itself. In simply scratching crossed lines on a beautiful carnelian, I have succeeded in producing a white cross on a red ground. In minerals this starry quality is very valuable, because it reveals the primitive form of the substance in which it is found, and I repeat that, by looking through a stone suitably cut, we find these luminous transverse bands in a great variety of crystallized minerals.

There is a very hard dust employed in the arts, called *emery*, a powder used in rubbing or grinding down bodies with hard surfaces. This substance is a species of corindon or sapphire, containing a tolerably large proportion of iron, which has been substituted for the aluminium at the time of the formation of the stone. This substitution is quite common in chemistry and mineralogy. It is believed that the Chinese succeed, by patience, in cutting diamonds with emery. This must be very slow work, because the stone of which emery is composed is very much softer than the diamond; it is like sharpening steel by rubbing it on paper or linen. However, if patience can work miracles, it is doubtless reserved for the Chinese to accomplish this result.

We shall place after the sapphire, the *opal*, which comes from Hungary and Mexico. The Hungarian opals are much the superior, and have not the disadvantage of deteriorating with time. Some years ago the opal was higher in price than the sapphire; but increase in value inducing a more active working of the mines, the price of opals, beautiful as they are, fell to what we find it at present. For the perfection of an opal, it should exhibit all the colors of the solar spectrum, disposed in small spaces, neither too large nor too small, and with no color predominating. The opal is sometimes called the harlequin, in allusion to the great variety of colors which it displays. The substance of the opal is of a milky hue and of a pale greenish tint. This milkiness is generally known by the term *opalescence*. It is the color of water in which a little soap has been dissolved. In order to explain the brilliant colors of the opal, we may imagine in the stone a great number of isolated fissures, of variable width, but always very narrow. Each fissure, accord-

ing to its width, gives a peculiar tint similar to the effect produced by pressing two plates of glass together: we may recognize violet, blue, indigo, red, yellow, and green, the last two being exhibited more rarely than the others.

As a proof that the brilliant colors of the opal are due, as we have said, to narrow fissures, similar colors may be produced by partially fracturing, with the blow of a hammer or a wooden mallet, a cube of glass or even a rock-crystal. Colors obtained in this way are known in optics by the name of colors of thin plates, and are of the same character as those of flowers, which result from the overlaying of the transparent tissues of which the petals are composed. Herein lies the secret of all their varied hues from their first opening until their final decay.

Sometimes the opal is colored only in its substance, has not so great a play of light as when it is variously traversed by fissures, and then it is not so much esteemed. Again, it may have extended fissures exhibiting a somewhat changeable single color—red, blue, yellow, or green. The Empress Josephine once paid a very high price for a pair of these stones, it being then the fashion to wear two bracelets exactly alike, and it was quite difficult to get two stones perfectly matched, since the interior disposition of the fissures of the opal, which gives its peculiar play of color, depends entirely upon accident. At present it is only the *harlequin* opals that are much valued, and those of Josephine would not now bring a tenth of their former cost.

Except for ear-rings, the opal should be set singly, with or without a surrounding of small brilliants, whose vivid lusters and scintillations contrast favorably with the tints of the opal.

The opal is not a very hard stone. In its chemical composition it is only hydrated quartz—that is, white pebble, combined with water. Heat, expanding its fissures, varies its colors, and pressure obviously produces the same effect. I have thus often changed, without permanent alteration, the colors of a beautiful Hungarian harlequin opal.

Before the revolutionary tempest, in the closing years of the past century, the financier d'Augny possessed a harlequin opal of great beauty. It was a perfect oval, 21 millimeters long, and from 15 to 16 millimeters in breadth. Esteemed as entirely perfect, the stone had a great celebrity. I do not know if d'Augny ran, like the senator Nonius, any risk of proscription during the years of terror; but certainly if he did, it was not on account of his possession of this unparalleled opal, since the wretched tyrants of '93, who sold to foreigners the treasures of St. Denis, and of many other churches, for 80,000 francs, did not dream of opals exhibiting all the colors of the rainbow.

The opal of d'Augny, the value of which I have nowhere seen estimated, passed some time ago into the hands of Count Waliski. The opal of Nonius, of the size of a hazel-nut, which he selected from among all his treasures as the companion of his exile, was estimated at 20,000,000 sesterces, which, according to the exact table of M. Dureau de la Malle,

in his book on the Political Economy of the Romans, is about 4,000,000 francs. Now, if we recollect that before diamond-cutting was understood, the opal was the only stone which, receiving the white light of day, gave it back refracted in a thousand magic tints, this price does not appear too much for a gem which was the *Koh-i-noor* or the *Regent* of Rome. The opal, at the same time that it is the lightest of all gems, losing in water one-half its weight, is also one of the softest. Those of India are somewhat superior in these respects.

In actual value the Paris market places, next after the opal, two stones of an undecided greenish yellow, viz, the *chrysolite* and the *peridot*. The first is characterized by its lively luster, its polish, analogous to that of the sapphire, and its warm bright tint. It is the "stone of affection" of Sir David Brewster, so celebrated for his researches in optics. The chrysolite, or *Cymophane*, has often the milkiness of the sapphire. To enumerate its other properties we must enter the broad field of modern optics, speak of double refraction, of polarization, and the colors which are exhibited in the light which traverses crystals, and finally of the three kinds of colored rings, namely, those with black lines, those with black crosses, and those without either lines or crosses. The rings in the chrysolite, as in the topaz, are of the first kind. This is not, however, a distinguishing property, since it can be made to appear, with a little dexterity, in almost all cut stones. As to the *peridot*, or *olivine*, its color is deeper than that of the chrysolite; it is always of a greenish olive, mingled with yellow, the green predominating; is very soft, scarcely scratches glass. Its lack of hardness gives an appearance of dullness to its edges. The *peridot*, which comes to us from India, is there used as ornaments of harness, as well as are the flatly cut emeralds of the same country. Ceylon, which is above all other places distinguished for the production of colored stones, does not continue to furnish the peridot, which, however, is not rare in the lava from volcanos, although the specimens are too minute to be worthy of the art of the lapidary.

I have often seen in the possession of an amateur interesting collections of these small crystals, which, viewed by lamp-light and under a microscope, verified all the crystallographic laws of Haüy. A crystal of a peculiar property, though of the minutest dimensions, was to this eccentric amateur what the *Star of the South* would be to an ordinary collector of diamonds. His long and minute investigations gave him great facility in the study of minute gems. From a stone covered with small crystals he would select one which, under the microscope, and properly lighted, would present the most interesting scientific indications.

The *peridot* has the distinguished honor to be the only precious stone that has thus far been found in aerolites falling from the sky, although these little olive stones are of no great value if sold by the carat; but if suitably cut in their matrix, they afford, if not very beautiful, certainly very curious, specimens. I need scarcely say that the existence of a crystallized stone found in bodies falling from the atmosphere refutes the

idea that these meteorites are formed suddenly by the condensation of exhalations from the earth. The regular disposition of the particles of a substance in the form of a crystal requires immense time as well as perfect freedom of motion.

From the *peridot* we pass to the *garnet*, which is a ferruginous stone of a deep-red color, and often wanting in transparence. It is, however, sometimes found of the beautiful color called peach-bloom. To the perfection of colors it is necessary that a specimen should join a regularity of tint, wanting which constitutes a defect easily perceived by an eye properly trained. There is sometimes found with cut garnets a very pretty assemblage of stones in juxtaposition, which gives a very agreeable appearance of black mingled with red. The only garnet I have ever seen of any value is the *hyacinthe*, a stone of a luscious orangy yellow color, having a little the appearance of candy made of brown sugar. This stone, which Haüy wrongly separates from garnets, is not much esteemed except by amateurs or collectors of curious specimens. The Hollanders formerly cut garnets into a pearl shape, which were strung in necklaces and used as money among the slave-traders. As in sapphires, *astérs* may be observed in garnets, and I have been able to verify, by the cutting, all that this phenomenon indicated of the structure of the stone.

In the garnet can be developed crosses with six and also with four limbs, besides straight and obliquo crosses, without counting certain circles of light resulting from a cutting perpendicular to the *astérial* filaments.

Both for mineralogy and also for optics the study of gems affords many important facts. It is to the study of mineralogical optics that Malus, Arago, Fresnel, and Biot, in France; Huyghens, in Holland; Wollaston and Sir David Brewster, in England; and Seebeck and Haidenger, in Germany, owe so much of their renown, and to which the science of light is indebted for its most beautiful discoveries.

Pliny gives no Latin name to the garnet, but confounded it with all stones of a red color, under the head *carbunculi*. It is the heaviest of gems, and like the diamond does not possess double refraction. From the white garnet of Norway very excellent microscopic lenses have been made, although it is ordinarily from the diamond that small and exceedingly powerful lenses of this kind are formed. The cutting of such lenses is very difficult, and the price commensurate with the labor and skill required in the operation. I may here observe that another mineralogical crystal having single refraction, the *amphigène*, strongly refractive and perfectly colorless, may also perhaps be used to form small, powerful lenses.

The *topaz*, whose name is derived from its yellow color, is a mineral which also crystallizes in prisms, and is susceptible of being very nearly broken transversely. They are of all colors, and come principally from Brazil and Saxony, though Siberia also furnishes them. The price of

the yellow variety, which, strictly speaking, only ought to bear the name of *topaz*, has wonderfully declined during the last quarter of a century. The Brazilian topaz cannot be confounded with the oriental, which is a beautiful corindon of a yellow color, deepening almost to orange.

Although the topaz is not considered a very brittle mineral, it is said that the Emperor Maximinius, who broke the teeth of his horse with a blow of his fist, and the leg of a beast by one of his royal kicks, was so strong in the hands that he could crush topazes as we crush a lump of sugar. The topaz has been for a long time a great favorite, especially with the Spaniards, but with the caprice of fashion it has of late years greatly declined in the estimation of the public.

It was on the white topaz of Brazil that Fresnel made the important discoveries of double refraction with two axes. It is, also, the topaz which bears the name of water-drop, which is made so often to pass for the diamond. In mineralogy this stone serves as one of the types of comparative hardness. Thus, we say a stone scratches glass, scratches rock-crystal, scratches topaz and sapphire, according to the various degrees of hardness. For example, the Brazilian topaz cannot scratch sapphire, which is one test of a diamond. The black diamond of Borneo scratches every stone, even diamond itself. As to the *peridot* and *opal*, they scratch nothing, not even ordinary bottle-glass, which I use in experiments of this kind; as to window-glass it has become too soft of late to be used as a test, since for economy it is now made with too large a proportion of alkali.

The blue topaz of Brazil has never as deep a tint as that of the sapphire; it is only an aqua-marine of superior quality. Of all topazes, the only one highly esteemed is that artificially colored, of a pale rose hue, by means of fire. For the specimens that we wish to experiment with we must choose those of a deep yellow or rich orange color. Afterward they are placed in ashes or sand and submitted to a red, or even a white heat, more or less prolonged. When they are taken out we find the tint changed to the light red of what is called *ruby balais* or *ruby brulée*, (burnt ruby.) The gay color of this ruby is very pleasing to the eye. A dilettante once remarked to me, "This stone has an amiable character." I was entirely of his opinion as to the moral of this gem, although there is certainly nothing very *sincere* in the means by which it acquires its beautiful tint. If, like the olivine, the topaz had been enveloped in volcanic fires, it would naturally have become a *ruby balais*, and no cloud would have rested on the truthfulness of its character.

The mineral species which the topaz forms is characterized by a certain quantity of fluoric acid, which it contains exclusively of all other gems. This stone, moderately heated, becomes electric and will attract light movable bodies. A delicate linen thread, suspended vertically from one end, is attracted by the warmed topaz as it would be by a stick of sealing-wax after being rubbed on cloth. The topaz shares this curious

character only with the *tourmaline*. This latter stone, of which we shall say very little as a gem, is highly prized in optics on account of its polarizing qualities, which are utilized in a great variety of apparatus. It is without any brilliant luster; and though proposed as a stone for mourning ornaments, to compete with jet, jewelers have not yet made up their minds to employ it for this purpose. For a really rich mourning-decoration, black diamonds are the gems to be used, as they have been in Portugal in decorating the crown-royal. The earliest specimens of tourmalines came from Ceylon through Holland. The red tourmaline of Siberia, called also *sibérite*, is pretty enough for a ring; it occurs in minute crystals. The amateur of whom I have spoken had in his collection very small *sibérites*, from Corsica, of a crystalline form and exquisite in color; they would have served as gems for the decoration of the Liliputians. There are beautiful green and blue tourmalines, which come from South America, and are called Brazilian emeralds and sapphires. The aqua-marine, the name of which indicates its sea-green hue, is a stone of a mineralogical character similar to that of the emerald, but little in demand at the present time. It is possible that there may be an augmentation in its price, since no new ones are received in market. This stone loses nothing of its appearance in artificial light, and it is sometimes curious to see a magnificent decoration of sapphires wanting in effect at night, while a cheaper one of aqua-marine is not only preserving its splendor, but seeming to gain in brilliance by candle-light. The English regard aqua-marine with the partiality the Spanish had for the topaz.

This stone takes a beautiful polish, and preserves it for a long time. It is less hard than the topaz, and possesses many optical qualities, on which our limits will not permit us to touch.

We come next to the *amethyst*, the name of which signifies a *specific against drunkenness*. It is a true rock-crystal of a beautiful violet color; it is essentially a daylight-stone. Nothing is wanting to this lovely gem but rarity. Pliny employs the word amethystize as synonymous with violetize. Modern savans, with their lynx-eyes, find a difference between violet rock-crystal and pure amethyst. The latter is characterized by a series of little undulated strata, which is wanting in the violet rock-crystal. There are specimens of colorless quartz which have a structure similar to that of the amethyst. When certain agates consist of very thin layers of a uniform thickness, they take the colors of the spectrum, and are called iridescent agates. It is probable that the myrrhine vases, whose value reaches some hundreds of thousands of francs, were cut from iridescent agates. Sir David Brewster has given the exact theory of this iridescence, ignorant that I had already done so before him in the reports of the Institute.

The same philosopher has also demonstrated that the color of sea-shells is also due to their surface being striated by undulating and closely approximated minute lines; for, if we take the impressions of

one of these shells in finely prepared wax, we get the colors as well as the form of the specimen. Myrrhine vases were sold at 70, 100, and 300 talents. The talent was about 540 francs. We may find among minerals many stones which, being cut, will make excellent gems. There is the euclase, a weak emerald in color, but not so hard as a real emerald. The *amphigène* is as pretty as the white sapphire. The prehnite is a tolerably good *céladon*. It is somewhat remarkable that researches in mineralogy have led to nothing new in the way of precious stones. This illustrates a remark of Humboldt that mineral nature is the same from one end of the world to the other, which cannot be said of either the vegetable or the animal kingdom.

There is no hope, then, of our finding anything beyond diamonds, rubies, sapphires, topazes, emeralds, and amethysts. The only resource is the laboratory. To obtain new gems man must not count upon nature but upon his genius.

In terminating the list of precious stones let us say a word about the white pebble or rock-crystal. This is nothing but flinty sand, crystallized and variously colored. Almost all false gems, so called, are made from rock-crystal or quartz. Thus rock-crystals, cut like the diamond, as Rhine diamonds and Alençon diamonds, are called false diamonds. It is only violet quartz which makes the true amethyst. Recently an attempt has been made, with considerable success, to imitate the yellow topaz with rock-crystal of the same color. There is developed in the stone a very rich, velvety, orange color. As to all the reflections, the tints, the degrees of transparence, or of opalescence—in fine, of all the forms which quartz, a veritable proteus, can assume, a volume would hardly suffice to detail them. Formerly rock-crystal was used for chandeliers and many other articles for which glass is now substituted. The ancients were cognizant of the power balls of rock-crystal possess to concentrate the sun's rays and of setting fire to bodies. Physicians also used them to cauterize certain wounds, in accord with the adage, "After medicine, the knife; after the knife, fire; after fire, nothing." These balls can likewise be employed as microscopes, especially when they are small. Minute nature might have been studied as well by the ancients as in our day had they been so inclined.

I have not mentioned turquoises, of which there are two kinds, both without transparency, One of these is made from the teeth of the mastodon and colored with copper, a *green céladon*. It is a kind of fossil ivory. The other is a true mineral of the same greenish blue color, and is a great deal admired; it costs about forty francs the caret. The turquoise is perfectly imitated by porcelain. This stone, without transparency, can scarcely be reckoned among gems; it is rather a kind of natural enamel. We have also omitted feldspar, which contains an alkaline principle, and which yields stones having a mother-of-pearl luster, but without colors. However, when feldspar is

of a golden-yellow tint, covered with little reddish spots, it is cut like a gem, but is at the present time very little known; it is called *aventurine*.

After the consideration of crystallized minerals in nature, we should attempt the imitation of them in the laboratory. I do not mean such imitation as paste and color produces. I refer to the reproduction as nature gives the gems to us, and propose the making of real precious stones, such as has been attempted in the case of the diamond. I have already said that Ebelman, at Sevres, has crystallized aluminium and silex thus making a true *spinella*. M. Despretz, in the experiments by which he has volatilized charcoal and the diamond, has also melted aluminium and silex. He has obtained from these substances little hollow spheres, lined inside with crystals, like the cavities which are found in mines containing crystals of various kinds. In all the experiments of Despretz, the exceedingly intense heat which he produced by electricity only served to dissipate the particles of the diamond without producing any crystallization. It is therefore evident that the diamond is not an igneous production. Its origin is probably electric; but what was the epoch of its first production from ordinary carbon, and where did its crystallization begin?

According to M. Boutigny, the carbon of the earth comes from showers of hydrogen, united with carbon, which watered as it were the earth when it was too hot to receive ordinary rains. We have not yet seen the bearing of this hypothesis on the crystallization of the diamond. I have already said that sulphur and carbon, in uniting together, produce a liquid as limpid as water or pure alcohol. Now, with this it might be well to try the following experiment: Having filled a strong iron bottle with the liquid, and having covered it with an iron stopper, firmly screwed into the neck, I would place it in an oven at 200 or 300 degrees centigrade of heat. At this temperature the iron of the bottle and the sulphur would possibly react upon each other and enter into combination. Now, the sulphur, uniting with the iron, would leave the carbon free, which might thus slowly arrange itself in the crystalline form. I merely propose this experiment, which might require a long-continued heat of uniform temperature, to illustrate the play of chemical affinity. It is possible the effect would be analogous to that which takes place when a porous body is plunged into a saline solution, which absorbs the water and leaves the salt crystallized on its surface. We should inform those who may be tempted to try this experiment, that the fluid within the bottle would acquire by heat an immense repulsive force, sufficient to break almost any vessel inclosing it, especially one of iron, after the metal has been acted on by sulphur. The old alchemists frequently met with serious accidents in their attempts to transmute mercury by overheating it in closed iron vessels.

We have just said that there is very little chance that nature will furnish us with any new minerals. We must therefore depend on the results of the laboratory, and examine every substance whose hardness,

polish, transparence, and crystallization render them suitable for gems. We may afterward discover the method of coloring them, which would not seem a very difficult task, from the fact that the coloring-matter is always a foreign substance, and that, in many cases, gems have already been artificially colored. Ebelman, by evaporating ether from silica, has obtained beautiful specimens of paste, exactly resembling opal. Though man may never be able to discover all the processes of nature in the production of objects of curiosity or practical utility, yet he is every day inducing her to disclose some of the secrets of her operations, either as she reveals them spontaneously in the changes of the earth or is forced to repeat them under the coercion of her own agents—heat, light, and electricity.

ETHNOLOGY.

ON THE LANGUAGE OF THE ABORIGINAL INDIANS OF AMERICA.

By George Gibbs.

Among the questions submitted for consideration at the meeting of the American Philological Convention in July, 1869, was the following: "What more efficient measures can be taken to preserve from destruction the languages of the aboriginal Indians of America?" This communication embodies the substance of my individual views, as then offered, and I now take the liberty of presenting them to your consideration in the belief that the Smithsonian Institution possesses the only appliances adequate to the task.

The introduction to this topic might suggest an account of what has already been done in the collection of materials on those languages; but this would involve a multitude of details, chiefly the names of books, to criticise which would be out of place. A very full catalogue of all dictionaries, vocabularies, grammars, and grammatical notices prior to the year 1858, was compiled by Dr. Hermann E. Ludewig, and published in London by the Messrs. Trübner, with corrections by the late Professor Turner. From this it appears that, with the exception of a comparatively small number of languages, out of over thirty distinct families enumerated by Mr. Gallatin, and not including those of Texas, New Mexico, Arizona, or the Mexican States, there are no grammars or dictionaries worthy of those names. Of the rest of those north of the present Mexican line nearly all that we have consist of mere word vocabularies, such as have served for the comparisons by which the various families have been distinguished. These are for the most part confined to the forms adopted by Mr. Gallatin, and are either of sixty or at most one hundred and eighty words, too few to allow any but very close affinities to be recognized, and many of the words ill adapted even to that object. Without disparaging labors of this kind, a very necessary preliminary to further examination, it is certain that they do not fill the requirements of philological science at the present day. The collections already published, and those in manuscript in the possession of the Smithsonian Institution, soon to be put to press, cover nearly the whole of the American and British possessions, with the exception of a few New Mexican pueblos and some scattered and unascertained tribes. With the publication of these last, what may be considered as the primary classification of the Indian tribes in those territories, on the basis of linguistic affinity, is about complete. To go beyond this some new standard is required.

I would suggest, in the first place, the preparation of a far more copious vocabulary, to be based on the ideas exhibited in the languages already known. The words should be arranged not alphabetically but according to subjects, as the only mode consistent with intelligent inquiry, and as permitting the distribution of special or local words; for instance, objects familiar to one nation and not to another. Such a vocabulary should consist of not less than fifteen hundred words, and an even greater number would be advisable. In selecting these words, particular reference should be had also to such as are radical or contain radicals, and plain instructions be given by which the collector, if he has leisure and inclination, may dissect them.

Secondly. A large number of well-digested phrases, based upon these words, calculated to draw out the different forms of speech, and from which the grammatical structure of the language can be deduced.

Thirdly. The preparation of a succinct and popular statement of the most striking peculiarities of some of the different languages as derived from grammars already published and of well-known authority. No one who has ever attempted, for the first time, to acquire an Indian language but has been foiled, over and again, by a want of knowledge how to direct his inquiries; and the most intelligent student has labored for a long time without success, where a slight clew would have guided him. Although there are certain characteristics which pervade almost all American languages, they yet differ greatly from one another in the degree in which these are marked, and often in the method in which they show themselves. Some languages, also, have evidently reached a far higher degree of culture, so to speak, than others. In fact, there is as much difference in the grammar and syntax of different Indian languages as in those of the Indo-Germanic stock. In many of them a modification of the numerals takes place according to the nature of the object counted, sometimes indicating whether the object is animate or inanimate, at others various other qualities, as form, &c.; and the number of these modifications varies from two in the Selish (one applied to the first, the other to the second class) to over forty in the Cakchiquel. In the Otchipwé, or Chippeway, language, on the other hand, where the nouns are all divided into animate and inanimate, there are a variety of changes in the cardinals, but none on that principle; while in their place there are certain numeral verbs which are animate or inanimate according to the object expressed. In the Cherokee this principle is not found either in the nouns or numerals, nor are the latter modified at all; but the modifications, which are numerous, including animate and inanimate, are confined to the verbs, many of which change according to the quality of the object in which the action terminates. For example, the verb "to take" is in English simple, no matter what is the nature of the thing taken, but in Cherokee there is one form signifying to take a pliable object, another to take a long object, others to take a liquid, an upright, or a living object, and the particles indi-

cating these go through all the conjugations, moods, tenses, numbers, and persons. It will at once be seen under what difficulties the student labors who is not forewarned of these modifications.

It would, of course, be unwise to swell a work intended for popular use, with all the nice distinctions of these languages, but it is desirable that the main features of some leading ones be pointed out; and in my opinion the best arrangement would be to take each part of speech consecutively, and to show those features as varying in different languages. Those persons who have time and leisure for closer and more intimate study could afterward refer to more elaborate grammars.

Such guides, in the nature of instructions, "How to Observe and What to Observe," should, of course, be disseminated widely through the Army, among missionaries, agents, surveyors, and other persons residing in or traversing the Indian country. It is hoped that in this way a stimulus may be given to the exertions of many who only require to know in what direction to employ their leisure and tastes.

In order to the fit preparation of complete and exhaustive works on the indigenous languages, it is, however, necessary that there should be fit collectors in the field. Among those who have given most time to the actual study of our linguistics but few can afford to devote themselves to procuring new material. It is chiefly by missionaries, and by the Catholic priesthood especially, that the most valuable works on the subject have been prepared. Willing collectors of vocabularies have not been wanting, but of trained men there are few or none.

It appears to me that to accomplish any thorough and satisfactory result, an attempt should be made to prepare the laborers. It is possible that a foundation may hereafter be created for a professorship in some leading college where the teaching of American philology will form an important item, if not its exclusive object; but that would, at best, reach only a few individuals. Some wider method must be adopted to instruct a larger number. There has, as yet, been little or nothing of "Universal Grammar" taught at any of our institutions. Grammars of special languages are taught, it is true, but with hardly an attempt to show the common sources whence these are derived, or to exhibit the phonetic changes undergone in the lapse of time and under physical influences, or to trace back the ideas which have developed, from single roots, words of widely different signification, and none at all to develop the principles lying at the root of all speech.

It is very true that in a short collegiate course, pursued for the most part before the mind has become mature enough to grasp at more than the facts of language, and where utility is the presumed basis, it would be impossible to include such training to any considerable extent, but the course might yet be pointed out for after-inquiry. When the time comes—and it is to be hoped it will before the last vestiges of the aboriginal tongues shall have disappeared—in which general grammar becomes a common part of education, the curious modes of thought

presented by the American natives will doubtless excite the interest of the student, and every opportunity be sought of gathering up their remains. How many languages which have arisen since primeval man first trod the earth have perished from its face, each indicating, to a certain extent, in its mere words and forms, not only the outward circumstances in which those races moved, but the degree of their mental culture and the character of their thoughts. Ethnology has no surer basis than an intelligent philology. One of the least functions of the latter is to bring together or distinguish races.

There is one important point on which I have said nothing. I mean the alphabetic system to be adopted. I am clearly of opinion that the Roman and Italic letters should be used wherever practicable, and that they are in most cases sufficient. The alphabet prepared by Professor Whitney for the Smithsonian Institution is simple and intelligible, though in particular cases it needs supplementing. Foreign characters and redundancy of diacritical marks are objectionable on many grounds. It is the difficulty with most systems, as with that of Lepsius, that they are beyond the comprehension of any but their inventors, or at least require too varied a knowledge and too great nicety for any practical use. When a work is undertaken by a European, other than an Englishman, it is better, perhaps, that he should write as in his own tongue. That will carry a definite meaning at least to those who understand its pronunciation, and will insure a degree of certainty not otherwise to be relied upon. The explanation, in writing, of unusual sounds is always a hazardous experiment.

The preparation and publication of such a vocabulary, phrase-book, and grammatical guide as I have indicated would, it seems to me, properly come within the objects of the Smithsonian Institution, and I feel assured, from the interest you have always manifested in original philological research, that the subject will at least meet with consideration.

ON ANTIQUITIES IN SOME OF THE SOUTHERN STATES.

By H. C. Williams.

Near Vienna, Virginia, *December* 30, 1869.

Agreeably to promise, I send to the Institution a few specimens of Indian arrow-heads, all that I have been able to collect. I regret that the number of perfect ones is so small.

In Franklin County, Tennessee, in the days of my youth, when the country was fast filling up by emigrants from the older States, Indian relics, such as broken pieces of pottery, pestles, axes, heads of war-clubs, and arrow-points, were of frequent occurrence. There was no memorial in that part of the country to induce a belief that it had been inhabited by any race of aborigines, but the general diffusion of the articles above

named may be received as satisfactory evidence of its having been a hunting-ground to some not very distant village or encampment. The burial-mounds near Chattanooga and Sparta indicate those places as headquarters of the tribes for a long duration of time.

The fragments of pottery were generally of a dark color, not very hard or compact, with white specks mingled through the mass as though small pieces of shells had been mixed with the clay, and had not been converted into lime by the process of burning. The pestles and other implements were fabricated from stones of different colors, apparently of a clay basis, and corresponding, in appearance, to rocks which are common to the Blue Ridge. No such rocks occur between the Appalachian chain and the Rocky Mountains. The arrow-heads were made from quartz, which of this kind is not found in that country, the siliceous minerals, except the sandstone, being more or less cherty, with a semi-conchoidal fracture, often associated with and sometimes embedded in the limestone below the coal seams. Rarely an arrow-head of this mineral was discovered.

The mounds near Chattanooga have been already noticed by your correspondents. I would it were in my power to direct attention to another interesting locality. Of this my only knowledge is obtained from a publication, I think in the year 1825, in the *Review*, a newspaper printed at Sparta, the seat of justice of White County. As well as my memory serves me, Dr. Fiske and some other gentleman made an examination of an ancient cemetery near that town, and, finding no remains of adults, came to the conclusion that the country had been inhabited by a race of pigmies. The graves were numerous, covering more than an acre, were generally three feet long and eighteen inches deep, with a "coffin" of slaty rocks. The bones were so much decomposed that they fell to pieces after a few moments' exposure to the atmosphere. Perhaps a file of the *Review* for that year may be in the Department of State, for in it were published the laws of Congress, and it was then the custom of the Department to bind and preserve such papers. I mention this to enable persons investigating Tennessee antiquities to avail themselves of the information furnished by writers who observed and described those interesting objects before they were changed or obliterated by the hand of civilization. In this connection no book will be so likely to arrest the attention of the curious as Haywood's History of Tennessee. It is to be regretted that this, one of the earlier books published beyond the Alleghanies, is now so scarce in the State where the author was one of the first and ablest of its jurists.

In closing this communication, intending in another to notice the locality of some mounds and fortifications not alluded to by any of your correspondents as I have seen, I will state that when on an excursion into the State of Arkansas in the year 1857, I came to a place where doubtless an immense number of arrow-heads had been manufactured. It was near the summit of a ridge about two miles north of the Hot

Springs, and west of the road that passes over the ridge. At that place there is an outcrop of the *milky white* variety, an intermediate stratum of the celebrated Arkansas *novaculite*. There the hill-side for about one hundred yards in length was literally covered by thin chippings of that mineral. Dr. Sibley and Dr. Dunbar, who explored the Arkansas, Washita, and Red Rivers during Mr. Jefferson's administration, mentioned in their report that they had discovered a place where Indian implements had been made. I have not seen the report for many years, and cannot say whether this is the locality alluded to by them, but think it is, for they were at the Hot Springs, and there is not another mineral in the State so well adapted as the *novaculite* to this purpose. This is the only place in the Southwest that I have seen which affords any evidence of the fabrication of implements used by a people whose history is unknown. At Santa Fe, in 1858, a gentleman showed me several arrow-points that had been formed out of the *obsidian* found in that country, and a few days afterward, in the village of Casa Colorado, I gathered up a small quantity of that mineral in thin flakes that had obviously been chipped off in fashioning arrow-heads. By careful attention to the mineral characteristics of those ancient implements, especially when composed of as rare minerals as the *novaculite* and *obsidian*, we may be able to trace the migrations of the people who used them.

The report of Dr. Sibley, no doubt, can be found in the congressional documents of the period or in the reprint of them by Messrs. Gales and Seaton. It contains information that would be appreciated by persons engaged in ethnological or philological researches. Among other things it states that two tribes of Indians, the Natchez and Tensaws, if my memory is correct, were at war, that one party was disastrously defeated, and escaped over the Mississippi into Louisiana. On making a halt, the first thing they did was to throw up a mound. This is the only record that I have seen of a mound being constructed within traditional history.

ETHNOLOGY OF THE INDIANS OF THE VALLEY OF THE RED RIVER OF THE NORTH.

By Dr. W. H. Gardner,
Assistant Surgeon United States Army.

The earliest explorers of Minnesota found the Dakotas occupying all this country they now roam over or have only lately ceded their title to. In prehistoric times what race dwelt here cannot be told; the burial mounds and crumbling skeletons, the "refuse heaps" and fragments of rude pottery, point to some branch of the "mound builders," but whether Nahoas, Toltecs, or Aztecs, will probably never be known.

About Big Stone Lake, Lake Traverse, and the west bank of the Red River of the North and the country adjacent, for many years past, the

Sisseton and Wahpeton bands of Dakotas have resided; almost as rude and ignorant as the lowest branch of the Athabascan stock, yet they are tractable and show a desire for bettering their condition. Their manners, customs, and language do not differ essentially from the other bands of the great Dakota Nation, save from the aberrant branches, the Yanktonais and Tetons; neither can those bands understand the Wahkantans, Wahpetons, Wahpecutas, the Wabashaw band, the Black-Dog band, the Red Wing band, &c. The language used by them is constructed on the well known polysynthetic plan, and is so well known that one or two dictionaries have been published of the language.

Polygamy is common among them, each brave having as many wives as he chooses and can support, but lately some of them have embraced the Christian religion and have "put away" all their wives but one. Their Christian system, ingrafted upon their former fetichism, has resulted in a curious mongrel theology, which would puzzle even Buddha to understand. They have the same cruel instincts that always characterize a race of hunters; hardly one has come under my observation that has not more or less of small scars upon the body, purposely made with fire or cutting instruments, to show they have "brave hearts," yet my experience with them in sickness has been that they bear necessary pain quite as badly as even negroes. Their tribal government is a rude democracy, if that can be called a government whose most binding law is the *lex talionis;* nor do they recognize any head or chief save him who is bravest in war and most persuasive in council. Their legends and traditions are too well known to require only passing comment. Some of them are pleasing and instructive; but the most of them are puerile beyond description, and it is very hard to tell what purpose of national or social economy they could possibly subserve. The most of them are detailed at length in "Mrs. Eastman's Legends of the Sioux."

Of the arts of life they are almost entirely ignorant; even the ceramic art, with which most of savage tribes are necessarily acquainted, they are now ignorant of, though it would seem that before their communication with the whites they knew something of this art and used pottery made by themselves to cook their food in. After communication with the whites, and a knowledge of metallic vessels for the purpose of cooking, the art of making pottery was gradually neglected until it has now been lost. At all events the Indians of these bands know of no way of boiling their raw food now save by digging a hole in the ground and covering it with the skin of an animal recently killed, into which are poured the water and the food to be cooked; stones are then heated in an adjacent fire and held in this novel pot until the meat is done. As to their cooking, Professor Soyer, Monsieur Blot, or the most wonderful *chef de cuisine* that ever raised a pot lid, would stand amazed to see the wonderful heterogeneous mass combined to make one of their *ollas*—beasts, birds, reptiles, and fishes, berries, herbs, and roots, thrown together into the pot all in *puris naturalibus*, and stewed into a disgust-

ing paste. And the amount of this one of these "sons of the forest" will eat, will cause even an anatomist to wonder at the distensibility of the human stomach.

Until 1861 those about this locality—chiefly Sissetons—lived entirely by hunting and fishing. About this time some of them were furnished corn and potatoes by their agent, and they commenced to cultivate the soil, but shortly afterward, from causes not relevant to mention here, the Dakota outbreak occurred. The Sisseton and Wahpeton bands were implicated with the others, and the distrust and animosities this has necessarily engendered have much delayed their civilization.

The men are rather over medium height, are well made, and many of them are intelligent-looking, some even handsome. The type of their heads, with their "low defective forehead," the vertical occiput, the prominent vertex, and great interparietal diameter, hardly need mention, though it is deserving of remark that the "low defective forehead" is not so characteristic of the crania of the Sisseton band as of some of the other bands of the Dakota Nation. Their shades of color show considerable variation; many of them on the parts of the body not habitually exposed are not darker than many brunettes with us, while others in the same band are of a deep bronze or even coppery brown color. As a rule their hands and feet are small and delicately formed, and as a people they are remarkably free from deformities. Their hard "struggle for existence" probably acts on the principle of "natural selection" to keep up the best and hardiest of the stock, while the weaklings and the deformed die off. I have seen but one deformed Indian during my stay here. He was a Wahpeton with a simple case of "hair lip," which its owner refused to allow me to operate upon. They are enthusiastic and excitable gamblers, and will stake their ponies and even their wives on a game of "moccasin." The females are short in stature and broad and more ungainly than the males; they possess great strength and great power of physical endurance, as is commonly the case among uncivilized tribes, where the women are the drudges and slaves of the males. I am inclined to the belief that the females arrive at the age of puberty before the age usual among civilized females. I have seen one Sisseton girl who was the mother of a healthy child—which she was nursing—when but thirteen years of age, and two or three who were mothers before they had quite attained the age of fourteen; though this precocity may be caused by the promiscuous intercourse of the sexes in their rude manner of life. Writers have spoken of the dreary existence of Dakota women, and nothing that has been said can draw too exaggerated a picture of the never-ending drudgery of their lives, uncheered even by the hope of happiness in the spirit land; therefore suicide is very common among them; even for trivial causes a Dakota woman will cut a thong of buffalo hide and hang herself. A case came under my observation a few weeks since, where the wife of one of the

scouts here hung herself to the ridge-pole of her tent just because her husband told her she should not make a visit which she wished to do.

Under the provisions of General Order No. 27, Headquarters Department of Dakota, St. Paul, Minnesota, dated May 19, 1867, friendly Indians have been enlisted as scouts and guides, since which time fifteen of them have been on duty at this post in that capacity. Those here are all full-blooded Indians of the Sisseton band of Dakotas. They are ambitious and zealous in the performance of their duties, and take a pride in keeping their clothes, bedding, equipments, arms, and horses neat and in good order, and I believe this is the testimony which all their commanders will give; and it shows that they can be made valuable auxiliaries in prosecuting warfare against Indian tribes "avowedly and obstinately hostile." Those on duty here show no repugnance or even disinclination to work, and the scouts have taken their regular tour of "police duty" with the rest of the enlisted men, and have shamed them by their willingness to do this duty.

One of the scouts here is tattooed with a "totem" of an open right hand, back to the front, placed vertically in the center of the forehead. This is the only instance which has come under my observation of any tribal or family mark or "totem" among them.

The Chippewas occupy the country east of the Red River of the North, in Minnesota, about the lakes forming the source of the Mississippi River and Red Lake farther north. Though they are occasional visitors to the post, they are situated too far away to be described as Indians about the post.

The valley of the Red River of the North on both sides is the peculiar habitat of half-bloods, (Bois Brulés, or Couriers des Bois,) a mixture of the blood of the lawless white traders (who until recent times were the only white people in the country) and Indian women. These half-bloods, the result of this mixture, are tall, well formed and hardy, with dark eyes and swarthy skin, and black, straight hair, though occasionally one is seen with the hair curly. The general shape of the head and face is much like the Indians. Their vernacular is a *patois* of the French, though they usually speak the language of both parents. They are natural-born hunters and trappers, scouts, guides, and interpreters, and are a valuable link of communication between the tax-paying citizen and the untamed red man. These people have no "local habitation;" like their half-brothers, the Indians, they live in tents of tanned buffalo hide, which they move whenever and wherever inclination or the pursuit of game may lead them. They have the same freedom from moral and social restraint as the Indian. They eat anything and everything, even the flesh of dogs and wolves poisoned with strichnine, and think a fœtal calf of cow or buffalo *une bonne bouche;* they wallow in dirt and vermin, and are remarkably healthy and tenacious of life. Their severe, laborious lives probably prevent them from being very prolific, but it also acts to make them healthy and long-lived. Even syphilitic diseases, which (with

the loose virtue of their women) it would seem would be particularly prevalent, do not appear to attack them at all. At least, not one of these cases among them has been brought to my notice.

ACCOUNT OF ANTIQUITIES IN THE STATE OF VERA CRUZ, MEXICO.

By Hugo Finck, of Cordova.

A few general remarks relative the traces left by the aborigines of this neighborhood may not be uninteresting. As a resident of twenty-eight years in this part of the country, (Cordova, Huatusco, and Merodor,) and during my many botanical excursions, I have had good opportunities to examine them. These traces are of two kinds—the first belonging to a semi-barbarous; the second to a half-civilized people, who, for a long period of years, must have lived together as neighbors, but in a state of continual dissensions.

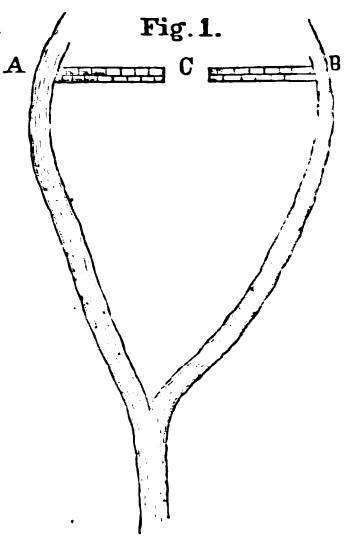
Like the actual descendants of the Aztecs, the semi-barbarous people built their houses, or rather huts, of light timber, covering the roof with palm-leaves or dried grass. Nothing else was required by them in a tropical climate, where the thermometer never descends below 55° Fahrenheit. Of such constructions no trace whatever is left, and if it were not for the innumerable mounds of stone of different dimensions, some united, others isolated, and which were always annexed to their dwellings, we would come to the conclusion, either that they had no dwellings, or that the country was very thinly inhabited. The very contrary was the case. There is hardly a foot of ground in the whole state of Vera Cruz in which, by excavation, either a broken obsidian knife, or a broken piece of pottery is not found. The whole country is intersected with parallel lines of stones, which were intended, during the heavy showers of the rainy season, to keep the earth from washing away. The number of those lines of stones shows clearly that even the poorest land, which in our days nobody would cultivate, was put under requisition by them; furthermore, when we consider that their implements of agriculture were very primitive or almost null, requiring a so much larger space of ground for their sustenance, we must come to the conclusion that the population must have been immense, or at least as large as the most populated districts of Europe. In this part of the country no trace of iron or copper tools has ever come under my notice. Their implements of husbandry and war were of hard stone, but generally of obsidian and of wood.

The small mounds of stones near their habitations have the form of a parallelogram, and are not over twenty-seven inches high. Their length is from five to twelve yards, their width from two to four. On searching into them nothing is found. A second class of mounds is round, in the form of a cone, always standing singly. They are built of loose

stones and earth, and of various sizes; some as high as five yards, with a diameter of from five to twenty yards. Excavation made in them brought to light a large pot of burned clay filled with ashes, but in general nothing is found. The third class of mounds, also built of loose stones and earth, have the form of a parallelogram, whose smaller sides look east and west, and are from five to six yards high, terminating at the top in a level space of from three to five yards in width, the base being from eight to twelve yards. They are found from fifteen to two hundred yards long. Sometimes several are united, forming a hollow square, which must have been used as a fortress. Others again have their outer surface made of masonry, but still the inside is filled up with loose stones and earth. Near river-beds, where stones are very abundant, these tumuli are largest. Principally in this latter class, idols, implements of husbandry and war are discovered, sometimes lying quite loose, and at others imbedded in hollow square boxes made of masonry.

The last-described mounds form the transition to those constructions which are altogether built of solid masonry. I speak only of such as are found near Cordova, Huatusco, Cotastla, &c., in the state of Vera Cruz. One peculiarity of the last-mentioned ruins is, that they are all constructed at the junction of two ravines, (barrancas, cañons,) Fig. 1, and used as fortresses, on account of their impregnability. Most of the larger barrancas have precipitous sides from three hundred to one thuosand feet deep, which guarded the inhabitants on their flank, so that nothing more was required than to build a wall from A to B, leaving a small entrance in the middle, C, as a passage, which could be barricaded in time of war. Between Zacuapan and Tlacotepec, at the Rancho del Castille, at Matlaluca, at Cotastla and Consoquitla, such constructions can be seen to this day in tolerable good condition. The interior of these fortified inclosures is in general large, sometimes holding from four to five square miles, and could be put under cultivation in case of a siege.

Fig. 1.



The wall A B is in general from four to five yards high, and has on the inside terraces with steps to lead to the top. At other places there is a series of semicircular walls, the front one lower than the following, and a passage between each to permit one person at a time to pass from one to the other. The innermost wall is sometimes perforated with loop-holes through which arrows could be thrown.

Quite a number of ruins are found inside the fortification, as mounds,

altars, good level roads with a foundation of mortar. Most of these monuments have good preserved steps leading to the top. In some very small pots of burned clay are found filled with ashes.

Between the simple mounds of loose stone and earth and the last-mentioned monuments we may easily discern two classes of people—one semi-barbarous and the other tolerably advanced in civilization—living continually at war with each other, impeding on that account a higher grade of civilization than that found at the arrival of Cortez with his Spaniards.

Civilization in all countries has been very gradual and must always have commenced in warm climates. It was in Asia, in Africa, in the tropical parts of China, Syria, Egypt, &c., where we find the oldest monuments, where the people as far as 3,000 years back had made some progress. The inhabitants of colder countries were, up to that time, in a barbarous state, and only received civilization by contact with the others or by conquest. This may be accounted for in the following manner: The first knowledge we have of man is in a tropical climate. It is there where vegetation the whole year round is luxuriant; where fruits of all kinds are abundant, furnishing him with food without exertion; where a hot climate dispenses with all covering against cold; where the first necessities once satisfied he had leisure, if endowed with a lively imagination, which is natural to people of hot countries, to set his wits to work in order to better his condition. One step followed another, creating daily new necessities. Those of a strong arm imposed on the weaker, and obliged them to work for them or for the community. In this way civilization gradually advanced.

Now let us transfer ourselves to a cold country. Its primitive inhabitants had to guard against the weather in winter, which obliged them to become hunters in order to slay the wild beasts which were to serve them as clothing as also to allay the cravings of hunger. Wild fruits could only be gathered in summer and autumn, and were much less abundant than in the tropics, so that their whole time was occupied in attending to the necessities of their existence, or in guarding against the cold of winter, being continually slaves to their wants, leaving them no leisure to better their condition. History has shown that such has been the case throughout all cold countries, and that civilization made very little progress there until the inhabitants came in contact with more southern nations. The same has happened in America. Where do we find the traces of higher civilization on this continent? Is it in British America, in New England, in Oregon, or in Patagonia? No! In tropical America. The same causes have created the same effect. Peru, Ecuador, Yucatan, and Mexico, all countries between the tropics, have taken the first steps toward advancement. The yet existing monuments speak for themselves.

From Palenque, in Yucatan, and Quito, in Ecuador, as centers, civilization spread north and south, but found much greater resistance by

the neighboring savage tribes than in the old continents. In some hot countries, as Guiana, Brazil, topical reasons have retarded this; as yearly inundations; excessive number of insects, particularly mosquitoes; wild beasts, &c.

After the first progress of civilization the neighboring savage tribes, among which we may count the Aztecs, who appear to have been in nothing different from our contemporary Comanches, Arapahoes, Sioux, &c., made, like of old the Scandinavians, irruptions on their more southern neighbors, destroying again partially what had been gained, but accepting part of the advantages of their conquered people. The inhabitants of Central America were much farther advanced before the dissemination of those barbarous tribes than at the arrival of Cortez. This is shown by the ruins still in existence. It was a great misfortune. Those savages, less docile than the Goths, were slow in receiving the advantages of their conquest. Accustomed to a roaming life, expert in war, they destroyed in a few years what had cost thousands to build. Then commenced a reign of terror. The vanquished were obliged to work for their conquerors, creating those rude monuments, as the stone-mounds, the pyramid of Cholulu, and other similar works, which could only have emanated from the brains of half-savages, and been executed by a people completely enslaved. But this had its limit. The conquerors gradually accepted such benefits from their vassals as suited them, so that if the Spaniards had not arrived, civilization would have taken a new start, as at this time the Aztecs were strong enough to keep at bay all new irruptions from the north.

Aztec hieroglyphics are too obscure to give us a longer insight into their history than for a century or two at most. Spanish historians have given free scope to their lively imagination, exaggerating and distorting whatever came under their hands. The Spanish clergy seized and burned what could throw any light on history, and wrote about what best suited them. The real and only true documents we can with safety count upon are the monuments, ruins, implements of industry and war, which are yet in existence; anything else will only lead us astray.

ACCOUNT OF ANTIQUITIES IN TENNESSEE.

By E. O. Dunning.

Chilhowee, Tennessee, *June* 19, 1870.

The territory recently explored by myself lies along Little Tennessee River, in Blount County, Tennessee, and extends about twenty-five miles into North Carolina, a country once inhabited by the Cherokees. One of their principal routes from the south to the "Over-hill Towns" passed through it. For miles the old trail may be seen crossing Chilhowee Mountain in a straight line, according to the Indian course, between

two points, which was always direct, without regard to obstacles. Lately I had an opportunity of observing this peculiarity. While winding my way around the base of a mountain in North Carolina, I saw some Cherokees going to the same point as myself, right over the crest of the mountain, by a more direct but more difficult route.

Chilhowee derives its name from two words, which mean fire and deer. The Indians were accustomed to hunt by fire. At night they carried before them torches—blazing pine-knots—in the face of their game, which, becoming frightened by the glare, were easily brought to a stand and killed by the hunter, who, resting his gun across the left arm, held the torch in his right hand until the deer was enough terrified to be shot down. The old trail over Chilhowee is used now by the "mail-boy" once a week, and by foot-travelers like myself, who are warned not to take horses beyond the mountain for fear of their being stolen.

In Chilhowee Valley, after crossing its northern boundary by the pass, I examined two mounds on the left bank of Little Tennessee and several rock graves, or tombs, near them. These tombs are unlike any depositories of the ancient dead that I have observed. They were, undoubtedly, constructed by the "mound-builders," as similar ones were discovered in the mounds containing similar relics. The great freshet of 1867 uncovered a large number of these graves on the "river-bottom" or alluvial terrace, which had been plowed over for seventy years. They are built of slabs of slate, nicely fitted together, about three inches thick, four feet long, and two feet broad, inclosing receptacles, not of uniform space—generally five feet long, four feet high, and two feet broad—covered with flat pieces resting upon the upright slabs, and conforming to the rounded corners of the tomb. The material had been brought from the other side of the river, as no slate was found in the vicinity of the constructions. They were found to contain, for the most part, fragments of human bones, too much decomposed to be removed in considerable portions, implements of stone, and broken vessels of clay. From the head of one I extracted a vase of black pottery, nearly whole, shaped like a gourd; it had been filled with vegetable matter, which, perhaps, was intended to sustain the spirit on its journey to the other world, some flint arrow-heads, and a stone pipe. Charcoal, ashes and burned clay indicated that fire had been used in the burial, by which bones and many other relics were consumed.

Judging from the form and size of these graves, the dead must have been inclosed in a sitting or crouched position, often bent nearly double. The bones were those of adults, and their juxtaposition, in some instances, showed that they could not have been deposited indiscriminately, after the decomposition or removal of the flesh, according to the custom of some modern Indians. Fragments of the skull-bone, with teeth and jaws, were found at the head of a grave which pointed toward the west, and the bones of the foot at the other end. In connection with the first were vertebræ and other portions of the trunk and cor-

responding members of the skeleton, which had crumbled and fallen down together, and which would naturally occur if the body had been set upright or slightly bent over.

I did not expect to find rock graves in a mound of earth, but after clearing away rubbish and penetrating six feet below the top, near the center, the workmen struck a slab of slate, which proved to be part of the covering of a stone tomb. It was much like those scattered over the "river-bottom"—more nicely constructed, however, and fitted with more care—being arched over the top, at an acute angle, with pieces of slate three inches thick. Owing to its situation, raised above the level of the river and covered with sand to the depth of six feet, its contents were better preserved than those of the graves just mentioned. At the head of it I took out a vessel composed of fine red clay and pulverized muscle-shells, a foot in diameter, gourd-shaped, having a handle and spout six inches long, and holding about a quart. It was preserved nearly whole. Artificial fire had been kindled in the tomb, but it had been smothered by the throwing in of sand before all the contents were consumed. Besides some entire bones of the human skeleton, flint arrow-heads and a large number of shell and stone beads were removed. The beads could be traced along the lines of the legs and arms, as if they had been attached to the garment in which the dead was buried. Further excavations disclosed two more of these stone sepulchers, the first three feet below the one described, the other two feet from it, in the same plain. They contained only fragments of bones, charcoal, and ashes.

The mound, which was conical in shape, must have been fifteen feet high and fifty feet in diameter. Successive floods had impaired its original dimensions. The last carried away a section on the west side, exposing a tomb and some valuable relics, which have not been preserved. Among them were large shells—pyrulas, probably, judging from the description, from the Gulf of Mexico—such as I have discovered in two other mounds on the banks of the Tennessee, and which are deposited in the Peabody Museum of Harvard College. In connection with marine shells, images in stone were found in this tomb. The mound was composed of sand-loam taken from the bank of the river and raised upon a foundation of water-washed rocks, four feet high from the bed of the stream hard by. There had been extensive burnings throughout this mound, at various depths, indicated by layers of charcoal, ashes, and burned clay, simply in honor of the dead or to consume their effects and mortal parts, or for human sacrifices to their manes.

As no relics, except fragments of charred bones, not even stone implements, that would escape destruction by fire were found, after careful searching among extensive layers, I am inclined to the opinion that captives in war were freely slain and burned, for a sacrificial offering to the dead in the tombs. It is not probable that a people so particular about their burial-rites, as shown not only in the mound-sepulchers, but in those scattered over the plain, which we may suppose contained their

common dead, would have assigned a large number of their tribe, after death, to a promiscuous or general conflagration. Fire, as is well known, bore an important part in the obsequies of the "mound builders," but so as to show neither in the extent and composition of the charred layers, nor in the kind of relics preserved, the design of the burnings. Two other mounds were found in Chilhowee Valley, which will be described at some future time. The tradition, as derived from a lady over eighty years of age, who lived in her youth among the Cherokees, is, that these mounds were made by a people inhabiting the country long before the recent Indian race; that their fathers found them there and did not disturb them, a statement which confirms all oral testimony respecting those monuments.

Leaving Chilhowee Valley and crossing the Alleghany range toward North Carolina, in a southeast course, having Little Tennessee River on my right and occasionally in sight from the cliffs, my attention was called, along the road, to "stone heaps," a class of antiquities not often mentioned and seldom distinguished in books. After an examination of the objects and a talk with Indians and the oldest inhabitants, I came to the conclusion that there were two kinds of these remains in this part of Tennessee, which are sometimes confounded, viz, landmarks, or stone-piles, thrown together by the Indians at certain points in their journeys, and those which marked a place of burial. At a pass called "Indian Grave Gap," I noticed the pile which has given its name to the mountain-gorge. The monument is composed simply of round stones raised three feet above the soil, and is six feet long and three feet wide. As the grave had been disturbed I could make no satisfactory examination of its contents. On the opposite side of "The Gap," a stone heap of another description was observed, which had been thrown together in accordance with Cherokee superstition, that assigned some good fortune to the accumulation of those piles. They had the custom, in their journeys and war-like expeditions, at certain known points, before marked out, of casting down a stone and upon their return another. In this way, in time, a landmark became a conspicuous object. It may be distinguished from grave-stone heaps, which were composed of large round stones of uniform size; the other of small stones, of no particular shape, such as could be easily taken up and hastily thrown down. Four miles from "Indian Grave Gap," on the west side of my path, on a ridge destitute of vegetation, I observed twenty-five of these stone heaps which covered human remains. I examined a number of them, which were four or five feet high and eight in diameter, and shaped like a hay-cock. Trees three and four feet thick had grown and decayed on some of them. In one I found pieces of rotten wood that had been deposited there, fragments of bones, and animal mold. The deposit had been made on the surface of the earth, covered with wood and bark, and crowned with a cone of round stones. From the center of one heap three small bells were extracted, having the letters J R engraved on them. They much

resemble sleigh-bells of the Northern States, and must have been obtained from Europeans having intercourse with the Indians. The bells were used as "tinkling ornaments" by Cherokee women in their dances, and were attached to bear-skin belts that were bound about their limbs.

The great number of rattle-snakes that I encountered on the ridge prevented a thorough examination of the place in the heat of summer, an employment that may be resumed at a future time.

The stone heaps were put up, undoubtedly, by the Cherokees of a recent period. My researches did not throw much light upon their antiquity, but they were found to differ essentially, in structure and contents, from the rock tombs of the "mound-builders," already described, and they must have had a later origin.

The Cherokee custom of burying the dead under heaps of stone, it is well known, was practiced as late as 1730. After free intercourse with the whites their custom of inhumation prevailed with the natives. Considering the dilapidation, the condition of the animal remains, and the decay of vegetation that indicated the former growth of trees of more than a century, I regarded those piles that came under my observation as being two or three hundred years old. The bells, silver ornaments, and coin discovered in them belong, of course, to the age of metals in this country, which may have begun on the banks of the Little Tennessee more than three hundred years ago. In 1690 trading-stations were established there by northern adventurers.

ACCOUNT OF ANCIENT MOUNDS IN GEORGIA.

By M. F. Stephenson, Gainesville, Georgia.

The most extensive and perfect tumuli exist in Bartow County, on the Etowah River, near Cartersville, consisting of ten mounds, situated in the bend of the river, and protected from attack on the land side by a moat, which is from twenty to thirty feet deep and was doubtless once filled with water. The central mound is square, and measures one hundred and fifty feet on the top,* with raised platform on the east side twenty feet high and forty wide, evidently where sacrifices were offered, as an idol of sandstone was plowed up on it, with excavated disks or mortars six inches in diameter and of translucent quartz of elegant workmanship, the stone axe, a small native copper vessel, the perforated shell, (which is found in all the mounds,) the mica mirror, and the only gold beads ever found, native gold being found in the neighborhood. This mound is eighty-eight feet high, and a few rods from it is a circular one, sixty feet high, which twenty years ago had a parapet on top five feet in height. The remainder are small and only about twenty feet high. Two points in the ditch are excavated an acre square as deep as the

* It is not exactly a quadrangle, but the north side is 150 feet; the eastern, 160 feet; southeastern, 100 feet; south, 90 feet; and the western side, 100 feet.

moat, to procure earth to raise the mounds. The valley and country for thirty miles westward and northward is very fertile, and exhibits evidences everywhere of having been densely peopled by the mound-builders.

At the falls of Little River, near the Alabama line, on the crest of the fall, are three chambers hewed out of the solid sandstone; and at Nacoochee the crest of a conical hill was cut off at about fifty feet, so as to embrace an acre and a half, which on two sides is quite precipitous, and on the others has a ditch and wall, which was formerly six feet high, inclosing about twenty acres. This was doubtless used by De Soto in the battle he had with the Cherokees in 1540, which is proved by the relics which have been found.

At Macon are stupendous remains, as also in Campbell County, on the Chattahoochee. The Yond Mountain, four thousand feet high, of solid granite, is a cone, crested with trees, but perpendicular on all sides except one space, which was walled with stone; so was the Stone Mountain, which is, without exaggeration, two thousand three hundred and sixty feet high, a cone, and accessible on one side only; this was walled with stone. All defensible mountains in this country were fortified. Neither the Cherokees, Creeks, nor Seminoles had any tradition of this extinct race, which is proved to have been a powerful and despotic nation from the extent of their territory and the stupendous character of their fortifications and cemeteries.

EXPLORATIONS IN TENNESSEE.

By E. A. Dayton.

Knoxville, Tennessee, *April* 9, 1868.

I left this place on Saturday last, and reached the house of Wm. Staples, in Roane County, on the evening of the same day. I went via Cross's Ford of the Clinch River; thence via Robertsville. The distance is about twenty-eight to thirty miles. Staples's farm is on the west side of Poplar Creek and on the line of Anderson County. On Monday I made an examination of the salt well or lick, and the Indian remains spoken of in the newspaper article I sent you. They are located a mile south of west of Staples's house, one-fourth of a mile from Poplar Creek, and on a small branch, in which the water was about three inches deep and four feet wide; it flows between hills, and a well is at the base of one of the hills which is about one hundred or one hundred and twenty-five feet high. The rock is a clay shale. The well is about five to five and a half feet in diameter, and is full of water to the top, which is about on the same level as the water in the branch. There was little or no water flowing from it. It was possibly a little brackish or sulphurish, but very little of either. The well did not appear to be *stoned up*, but

to have been dug through the loose shale rock. I ran a pole down into the water and mud from twelve to fifteen feet, and it did not then touch hard bottom. A quantity of logs and sticks had lately been taken from the well; they were much decayed. On the opposite side of the branch, and a little down it, say about sixty to seventy-five feet from the well, were Indian remains. They covered a space of about thirty by fifty feet, and about three to four feet above the water in the branch. The soil is a vegetable mold from six to eighteen inches deep, through which are found fragments of earthen-ware, ashes, and burned stones. I dug a trench, twenty feet long and as deep as any remains were to be found, along the center from one side of this place. The bottom of the branch is the shale in place, and there is no deep soil, that about the well being about a foot deep, made up of loose stone. This place was pointed out to me by Mr. Staples as being the one spoken of in the paper, and where he had found fragments of earthen kettles of a diameter, as indicated by their curvature, of over three feet. Half a mile east of the dwelling of Mr. Staples, on a low ridge, and about the same distance west of Poplar Creek, are three mounds. They are on nearly a straight line north and south, and one hundred and fifty feet apart. The south one is fifty feet in diameter and six and a half feet high, round and oval on top. They have all been plowed over for several years; very small fragments of bones are found about them now, and I was told that human remains were plowed up on all of them. I dug a trench across the center of the south one, nine feet long, seven and a half deep, and two wide; I went below the streak of black soil the mound was built on. The earth of the mounds is of the same color as that in the fields on all sides, only it was streaked a little with darker colored earth. The middle one of the mounds was only about four feet high; I did not dig into it. The north one was about sixty feet long from the southeast to the northwest, of an oval shape, and about forty feet wide. I dug down into this one about three and a half feet, and found nothing. In the fields I found a quantity of arrow-heads, but not a particle of pottery. A third of a mile to the southeast, on lower ground, is another mound a little larger than the first one described. I did not dig into it.

I left Mr. Staples on Tuesday morning, and traveled via the old salt-works, three miles up the creek from his house. Salt was made here years ago, before the completion of the railroads; and Staples made some there during the war, using the coal obtained from the hills only one-half to three-fourths of a mile from the well; but as the brine is weak it does not pay now to work the well. I reached the house of Alfred Cross, on the west side of Clinch River, and five miles down it from Clinton, about noon. I had heard of the finding of many Indian relics on the opposite side of the river, on the lands of George and John Johnson, they having been washed out of the soil on the river-bottom by the flood of last year. I crossed the river and went to the house of C. R. Robins. A negro man in his employ had found and gave me the shal-

low round dish I send you, and the soapstone pipe. The piece was broken out of the side after it was found. Of Robins's people I also got the jar, and the smaller jug, or whatever it may be called. I then went to the Johnson's; they had had two larger vessels than these, but let the children use them for playthings, and they broke them up. Jerry then showed me to the place on the river where these things had been found; the water is now twenty-five to thirty feet below the level of the bottom, and it was covered, judging by the marks, along the higher land, six to twelve feet deep. Along this bottom, for one-half to three-fourths of a mile, and for one hundred to three hundred feet from the bank, every yard of the soil has fragments of pottery, burned sandstones, and shells, and flint fragments, but I did not find a single arrow-head here. At the lower end of this bottom the water washed out the soil three to five feet deep in spots, covering from one-half to one acre. In these pits were found these vessels. I could see along the banks of these pits that the remains reached to a depth of only twelve to sixteen inches. The soil did not appear to have been washed off only where these pits were excavated; nor was there any appearance of mounds, and I was told that there never had been any on this bottom. Last year the field was in corn; this year, wheat. Many of the specimens of earthen-ware appear freshly broken, as if done in plowing. I saw many very small fragments of bone, and I believe that there is now a large quantity of these earthen vessels buried in the ground, for these I have, must have been buried, and for a purpose. The owners would certainly have thrown away only the broken ones. I had no time to dig, and only stopped my surface search at dark. Wednesday I traveled up the west bank of the river to Alfred Taylor's. Here the water had washed the soil off of some three to five acres, and there were great quantities of burned sandstones, fragments of flint, &c. Very few fragments of earthen-ware were to be seen here. Here Mr. Taylor said that the flood of 1862, which was much greater than that of 1867, washed out many articles, bones, &c.; one, a stone jar, some person carried away, as well as many other things; but I could not hear of any of them being in the neighborhood at the present time. You will see by the large fragments of soapstone that they likely made vessels of that article. I hear of other places, one Watson's Island, where there were many articles washed out by the flood, and there are a great number of mounds along the Tennessee and its branches; and if there are any questions in regard to the mound-builders yet unsolved, I think this country the place to solve them in. Did they bury their dead in the bottom or on the top of the mounds; or did they bury them in or near their villages; and did they bury one of the jars or pots with them; or was something hidden in the buried vessels? I think that nothing but careful digging will solve these questions.

SOME ACCOUNT OF THE SARCOPHAGUS IN THE NATIONAL MUSEUM NOW IN CHARGE OF THE SMITHSONIAN INSTITUTION.

By Rear-Admiral A. A. Harwood, U. S. N.

Washington, *December* 17, 1869.

I recognize this sarcophagus as one of two monuments removed from elevated grounds just in the rear of Beirut, in Syria, and embarked on board the United States frigate Constitution, the flag-ship of the Mediterranean squadron, of which I was at the time first lieutenant. I left the ship shortly after, and on my return to the United States learned from reliable sources that one of the sarcophagi referred to had been presented by Commodore Elliott to Carlisle College, in Pennsylvania, and that the other, after having been offered to General Andrew Jackson to be buried in, and the old hero's declining the honor, was deposited in the Patent Office as the tomb of the Emperor Alexander Severus.

As you have probably observed, there is no inscription on this coffin, (to give it its English name;) consequently who the occupant was, or what his position, is a subject of pure conjecture.

The somewhat profuse carving upon it might suggest that its former tenant was "well to do in the world," but the style is hardly chaste and simple enough to encourage the supposition that he or she was of imperial or patrician rank. Nevertheless, for nearly twenty years this relic was exhibited in a public building of the metropolis, labeled as the last resting-place of the Emperor Alexander Severus, and nobody took the pains to question the accuracy or expose the absurdity of the legend.

It was found *near* to the one referred to as having been presented to Carlisle College, which is inscribed with the name of "Julia Mamaea," and in virtue of that fact assumed to be the coffin of the Roman Empress of the same name, and the wish thus becoming "father to the thought," the contiguous receptacle was incontinently credited as having contained the mortal remains of her imperial son.

Any respectable coffin in the same grave-yard would have had as good a claim to the honor of having inclosed an emperor; but after all, the first step to be taken should have been to ascertain who the Julia referred to by the inscription was. She might have been a relative of the Empress, the mother of Alexander, both because the Empress was of a Syro-Phœnecian family, and because the style of the sarcophagus, incorrectly represented as hers, is simple and elegant, and such as might have contained the bones of the kinswoman of an empress, but the inscription, which I copied carefully at the time, very conclusively establishes the fact that she was not the Empress Mamaea. It runs as follows:

IVLIA. C. FIL.
MAMAEA
VIXIT. ANN. XXX

which, if I have not lost all my Latin, means Julia Mamaea, daughter of Caia, lived thirty years.

The Empress Julia Mamaea was not the daughter of Caia, but of Julia Soemias; the legend on her tomb should therefore be I. FIL, and not C. FIL. Then she was killed in Gaul with her son Alexander, in a mutiny of the soldiers, on the same day.

According to the best authorities, he was just thirty years old when this event took place. None make him more than thirty-three. Assuming the least probable as the date, then, if the sarcophagus at Carlisle College be that of the mother of Alexander Severus, she must have given birth to her son when she was but three years old, which is, to say the least, unusual.

In brief, that the sarcophagus now deposited at the Smithsonian Institution was taken from an ancient cemetery at Beirut, in Syria, and brought to the United States by Commodore J. D. Elliott, in the frigate Constitution, and by him deposited in the Patent Office, and thence transferred to the Smithsonian Institution, would be a plain and truthful label to put on the relic.

ACCOUNT OF THE DISCOVERY OF A STONE IMAGE IN TENNESSEE, NOW IN POSSESSION OF THE SMITHSONIAN INSTITUTION.

By Edw. M. Grant.

Nashville, Tennessee, *August* 12, 1868.

The history of its discovery is as follows: Near Strawberry Plains—a station of the East Tennessee and Virginia Railroad, about sixteen miles east of Knoxville, Tennessee—there is a cave, one of the many hundreds of those natural curiosities that are to be found in the belt of country lying between the Ohio River on the north and Northern Mississippi, Alabama, and Georgia on the South, the Mississippi River on the West, and the Atlantic Ocean. This cave is in the direct line of march of De Soto's expedition to the Mississippi River; many of his forts, and other traces, being still visible at the present day in that section of country. In the early spring of 1867 I had a force of men building the large bridge over the Holston River at Strawberry Plains; and during one of the various visits that I made to the work I saw this stone image, which had just been found in the cave referred to, about one-half mile from its mouth, I think, by a man named Douglas, who was wandering about in the cave one Sunday. It was attached to a stalactite or stalagmite at the back of the head, where a fresh portion of the rock can now be observed, evidently having been chiseled from one of the formations mentioned, an operation that required considerable skill and patience, as the red Tennessee marble, which it is cut from, is very hard, and its crystalline formation renders it very difficult to carve. Douglas

was away from home at the time, and consequently I could not obtain it from him. My evident desire to possess it, however, attracted the attention of my foreman, Mr. B. F. Price, and after Douglas returned Price purchased it and sent it to me by express as a present.

It has been examined by several persons who have paid considerable attention to Indian antiquities in the South, and none of them has ever seen anything like it. Traditions here indicate that the tribes who inhabited this country were not idol-worshipers; still, this may be erroneous. The cave in which this image was found has never been explored. I believe the inhabitants in the neighborhood are too superstitious to make many explorations in such places, and the finding of this image did not tend to allay their apprehensions; consequently there may be many other traces of the worshipers of this idol in the mazy passages of this subterranean labyrinth. Very few of the immense numbers of these caves have ever been thoroughly explored. Some of them have been traced many miles, and hundreds of passages, in every direction, discovered, but no termination was reached in any of them. I have been in one of these caves that I think surpasses the far-famed Mammoth Cave of Kentucky.

I believe that the belt of country referred to in the beginning of my letter is richer in interesting features of geology, mineralogy, antiquities, &c., than any other section of this continent. It is a region that never has been scientifically surveyed, and promises a rich field for the naturalist, geologist, and mineralogist, as well as the antiquarian.

ON MIXED RACES IN LIBERIA.

By Edw. D. Blyden.

[The writer of the communication from which the following extracts are given is a pure negro, a native of St. Thomas, and now professor in Liberia College. The letter was addressed to a member of the board of directors of the American Colonization Society.—J. H.]

Monrovia, *October* 6, 1869.

My Dear Sir: I send inclosed a catalogue of all the students who have ever been in Liberia College. It will be seen that not only were they not natives, (aborigines,) but more than three-fourths the number have been largely mixed with Caucasian blood, and among these death and disease have made sad ravages.

The great practical difficulty in the way of succeeding with our schools is the lack of suitable teachers. It is sad to relate that notwithstanding the thousands of dollars spent annually here by the different missions for educational purposes, there are still but very few teachers to be found, especially among females, able to conduct properly an elementary

school. The reason is that pains and money have been bestowed upon persons largely mixed with Caucasian blood, who, if males, have mostly died, or if females, have got married and assumed the cares of a family. It seems that the females of mixed blood, who are not obliged to put forth much exertion, and not subject to much exposure, last longer than the males. It appears, also, that mulattoes born and brought up in America, if they can pass through the acclimating process, stand the climate much better than those born here, but only by engaging in as little physical or mental labor as possible. Persons having an admixture of foreign blood are very frail, easily take cold, and seldom recover from a severe attack of illness. This will account in part for our want of enterprise and progress here. Such men have had the lead and management of things, and, by the fearful example of their disastrous inactivity, have been obstructive guides, discouraging all energy and *go-a-headativeness.*

Before the question of race came up here, mulattoes died just as they do now, but it was not noticed. Their mortality was put down to the general unhealthiness of the climate. But since Professor Freeman, in his address of July, 1868, called the attention of the people to the startling history of mixed breeds on this coast for the last two hundred years, the mixed classes have been watching with alarm the numerous indications of the frail tenure of their existence.

I have been for the last eighteen years connected with educational matters here, and feel safe in giving it as one reason why we are no better off in men to take charge of schools and churches, that the attention of educators has been principally devoted to persons of feeble constitutions.

The idea was that the presence of white blood imparted greater aptitude for learning, and such persons were to be fitted for teachers. Black boys of hale and hearty *physique* were left to grow up unnoticed. Many of them have taken to sea-faring life, or gone to reside as permanent traders among the natives, who might now be active workers in our destitute fields. But with all the advantages afforded to the miscegens, still the only professors for the college yet produced in Liberia are pure negroes; and the only man with enterprise, energy, and talent enough to explore the interior, calculate distances, and construct a map is a pure negro; and in the future, if we have any scientific men here, botanists, mineralogists, chemists, &c., they are sure to be pure negroes, and perhaps from the native tribes.

But what has become of the half and three-fourths white *protegés?* In the Alexandria high-school we had Armistead, Miller, Fleming, Melville, Augustus, Fryzon, Samuel D'Lyon, Colston, Waring, James H. Roberts, all are dead. In Liberia College, we have had James H. Evans, J. J. Roberts, jr., Beverly Russell, J. T. Chambers, John Henry, J. H. Harris, Edmund J. Payne, all dead. J. W. Leone is a raving maniac, and may die at any moment. In connection with this, I would

like you to read a letter which I wrote last year to Mr. William Tracy, of New York, dated September 11, 1868. Facts, it is said, are God's arguments. I venture to affirm that if the names I have just cited had been negroes, three-fourths of them at least would have been living to-day; for in all that space of time I know of only one negro connected with either institution who has died, N. R. Richardson, of sunstroke.

Now, who is to blame for these things? No one in the past; but if they are continued in the future, after God has presented his arguments, then those who continue them must be blamed. I do not charge guilt upon any one in the past, for I believe that these things were not done at the instigation of wrong passions, but under the delusion of a false theory. And you, gentlemen in America, proud of your race and blood, have thought, perhaps, that it must, as a matter of course, endure here, when strengthened by a negro basis, and bring to the negro an accession of improving mental qualities. But your theory has not stood the test. So far as physical health and vigor are concerned, I would rather take my chance here as a pure Caucasian than as a mongrel. The admixture of the Caucasian and negro is not favored by Providence in inter-tropical Africa, whatever may be the case in America. Let me beg you to look at this matter at once before wasting any more thousands upon an impracticable scheme. God does not intend that the Egypt of America shall be reproduced in this African Canaan. If persons who are half and three-fourths Egyptian could live and thrive here, if the families whose disappearance and extinction I have noticed in my letter to Mr. Tracy could have lived and carried out their views, and gratified their tastes, we should long since have had a miniature Egypt here with its caste feelings and prejudices.

The friends of the negro in America must learn to believe that the negro can exist and prosper without the aid of white blood in his veins.

Now that slavery is abolished in America, and the blacks are being educated, it is to be hoped that all good men will discourage, as far as possible, the "miscegenation" doctrine. The negro race is injured by it far more than the white, for by prejudice the nondescript progeny is consigned to our side, even if they are three fourths or seven-eighths white, and thus involve us in an inextricable "muddle." This is certainly a vexed question. But the higher plane to which the American people have attained by the recent revolution has given them loftier views and wider sympathies, and has furnished the means of education for the negro, which will supply the transition process from his low estate to a more intelligent and respectable position. Respect for the negro is becoming more and more, in the progress of events in America, the happy distinction of our age. The negro is being taught to respect himself, and soon he will think it no honor to mingle his blood with that of the Caucasian, Indian, or Mongolian.

ON SHELL-HEAPS.

By Rev. James Fowler, of New Brunswick.

I have lived for a number of years near the coast, but have never enjoyed the pleasure of discovering any of these heaps, and, as the result of my inquiries, have come to the conclusion that none such are to be found along the shores of this county or the neighboring county of Northumberland. Their absence may be accounted for by the fact that the whole coast is very low, and, being composed of the soft sandstone shale of the carboniferous formation, is constantly wearing away by the action of the waves. Within the last ten years the sea has encroached several rods upon the land. At Bay du Vin a church was erected about fifty years ago at such a distance from the shore that it was thought the sea could never reach it, (the bank or cliff being ten feet high,) but the church toppled into the sea five or six years ago, and the burial-ground that lay around it will soon have disappeared. Ten years ago a single storm, in October, removed the coast-line from four to five rods inland in exposed situations, and changed the appearance of long stretches of the shore. If shell-heaps ever existed on this coast, they must long ago have been swept away by the constant encroachments of the sea. Again, there are portions of the mainland protected by outside beaches running parallel with the coast and separated from it by distances varying from a few rods to a mile. These are composed of loose sand, and are continually changing their positions, owing to the action of winds and tides, so that any heaps that may have accumulated on them must have been buried or swept away long ago.

The coast of the Bay of Fundy is composed of harder rocks than our coast, and is consequently better fitted for preserving any deposits on the banks. I do not see, however, why heaps should not be found in some of the more sheltered bays or recesses of the coast, but I have not yet been able to discover their existence.

I have made inquiries about the stone implements of the aborigines, and have succeeded in securing two arrow-heads and an ax. Several have been found in this locality; but as those who find them are ignorant of their value, they never think of preserving them, and they soon disappear, or are broken up by children. Should these I have be of any service I can forward them.

I regret that I am incapable of furnishing you with more positive information, but negative conclusions are sometimes valuable.

ON THE USES OF THE BRAIN AND MARROW OF ANIMALS AMONG THE INDIANS OF NORTH AMERICA.

By Titian R. Peale,
United States Patent Office.

The uses of the brain and marrow of animals among savage people having become of interest in connection with the ethnological researches which are being prosecuted with so much ardor in this and other countries, a brief exposition of the facts relative to the subject, observed by myself, and collected from the writings of others, may not be unacceptable for the Smithsonian report. It may not, perhaps, be improper to state, as introductory to the subject of this communication, that I am, with one exception, (that of General Swift,) the only survivor of the celebrated expedition of Major Long to the Rocky Mountains. We owe this delay of the inevitable summons of the grim messenger principally to the fact that we were the youngest of a party numbering twenty-six. I was appointed as assistant naturalist and draughtsman of the expedition, and, among other duties, was directed by the letter of my instructions to give attention to the method employed by the natives in the preparation of the skins of animals killed for food or for their furs.

The material used for the preservation of the skins is principally the brains of the animal from which they were taken. While the skins are fresh, or in their green state, they are stretched on the ground, and scraped with an instrument of bone or stone, resembling an adze; the adhering portions of flesh are removed, and the surface is then plastered over with the brains, mixed in some cases with the liver, and on this is poured, from time to time, warm water in which the meat has been boiled. The whole is then suffered to dry, after which the skin is again subjected to the action of the brain and hot water, further stretched, and, while still wet, scraped and rubbed with stones until perfectly dry. It is further softened by rubbing and passing it backward and forward over a twisted sinew, stretched horizontally. The brain of an animal is sufficient to dress its skin; but, in some cases, a less quantity is sufficient for the purpose. I have myself used this process in the preparation of skins, but have found animal brains inferior, as a curing material, to a mixture of saltpeter and alum. The Indian, however, has no choice, and makes use of such materials as he can procure, and which, probably from accidental discovery and subsequent experience, he has found to produce the desired effect.

The marrow of bones of animals has generally been esteemed as a luxury, and among the Indians of this continent is held in high estimation, particularly that of the bones of the buffalo, the elk, the moose, and the deer. The round bones of these animals are roasted on the coals or before the fire, then split with a stone hatchet, and in some cases with a wedge driven in between the condyles when the bone has these ter-

minations. The marrow is then scooped out with a piece of wood cut into the form of a spoon, and eaten on the instant by the members of the party, seated around the camp fire. A feast of this kind can only be fully enjoyed after a successful hunt. When the marrow is collected in quantity for storing during the hunting season, which occurs usually twice a year, the bones of the larger animals are broken into small fragments and boiled in water until all the marrow which they contain and the grease which adheres to them are separated, and rise to the surface, when they are skimmed off and packed in bladders, or in the muscular coat of the stomach and in the large intestines, which have been previously prepared for this use. Not only is the marrow of the large bones of the limbs preserved in this manner, but also that of the vertebral column. The bones of this are comminuted by pounding them with a stone hammer, similar to those which are plowed up in the Eastern States.

REPORT OF AN EXPLORATION OF ANCIENT MOUNDS IN UNION COUNTY, KENTUCKY,

Made by the request and at the expense of the Smithsonian Institution.

By Sidney S. Lyon.

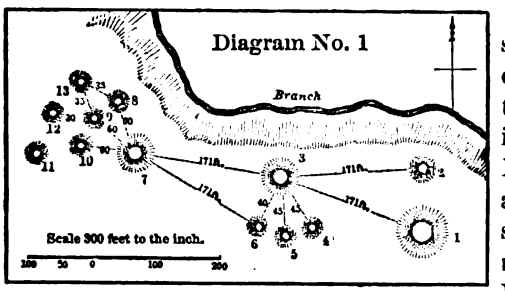
JEFFERSONVILLE, INDIANA, *July* 29, 1868.

I have made to the Institution the following shipments: First, from Shawneetown, one box containing casts of all that was left of the famous "Foot-print Rock," the last of this rude carving having been destroyed or removed since my examination in 1858. Second, four barrels of specimens from the Lindsay mounds, or that from which was taken the parcels sent by myself several years since to the Institution. These articles were taken from the land belonging to Leonard Roberson, but the property has since changed ownership. Third, three barrels and three boxes; the barrels contain articles from mounds 37 and 38, shown on diagram No. 6; box No. 2 contains articles from the Lindsay mound, and a few from other places; box No. 3, articles from McCoughely's mound, in the rear of Raleigh, Kentucky; box No. 4, some of the best articles from mounds 37 and 38.

The results of this exploration have been of less interest than I expected. I encountered unforeseen difficulties. The greatest trouble was to get and retain good laborers, and the utter impossibility of boarding them near the field of operations. During the last twenty-two days the men had to walk four miles to and from their work, with the thermometer at 95°. An expedition, to operate most efficiently, should be provided with tents and encamp near the work. The company should be organized before starting and not depend on assistance which may be procured in the country. There is a great field for investigation on both sides of the Ohio, near the mouth of the Wabash River. The people of the country have little or no exact information as to the number or location of the mounds. When a field is cleared inclosing a mound, and bones are ploughed up, the fact becomes known, but the existence of mounds in the woods or on the ridges is almost unknown; and as they are undoubtedly very numerous an explorer would find work enough to do.

I send you diagrams of some of the groups I have examined, with an account of their character, and of the facts obtained during the forty-two days of our exploration. I hope the results of my labors may prove satisfactory to the Institution, although they are not all I could have wished.

The diagrams of the groups of mounds are not deduced from exact surveys as to course or distance, the bearings having been taken by a common pocket-compass and the distance measured by stepping.



This group consists of three sub-groups. The one most eastwardly is composed of two mounds. No. 1 is 80 feet in diameter and 10 feet high; No. 2 is 40 feet in diameter and 4 feet high. The middle sub-group consists of four mounds 171 feet* distant from Nos. 1 and 2; Nos. 4, 5, and 6 are severally 45, 45, and 40 feet distant from No. 3, which is 60 feet diameter and 8 feet high; Nos. 4, 5, and 6 are 33 feet diameter; Nos. 4 and 5 are 3 feet high; No. 6 is 5½ feet high.

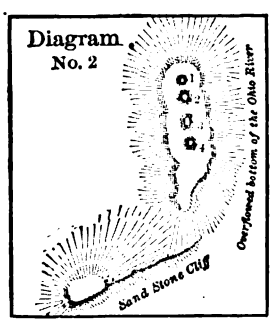
The most westwardly sub-group consists of seven mounds. No. 7 is a large one, about 70 feet diameter and 10 feet high; Nos. 10 and 11 are 4 feet high; Nos. 8, 9, 12, and 13 are 3 feet high; Nos. 8, 9, and 10 are 60 feet from No. 7; Nos. 11, 12, and 13 are from 33 to 35 feet from the bases of Nos. 8, 9, and 10 severally.

This remarkable group of mounds is situated in Union County, Kentucky, about two miles from the ferry-landing opposite Shawneetown, and about half a mile south of the "foot-print rocks." Mounds Nos. 1, 3, 6, and 7 were opened near the center many years since by Dr. Gieger. I could not learn if anything had been taken from them. The appearance of disturbance left by the excavation of Dr. Gieger indicates that the openings made by him were not sufficient to develop the full contents of the mounds.

I opened mounds Nos. 2 and 4 by digging a ditch about 5 feet wide from the margin of the mounds to the middle of each, expanding the opening at the center to a circle of 8 feet. The ditch and center of the mounds were excavated to the original soil; nothing was found in either.

The mounds 2 and 4 were begun on the soil and composed of a loose sandy loam, probably obtained in the neighborhood.

Nos. 1, 3, and 7 are large mounds, the others are low and flat and have the appearance of the mounds which I consider as *common* burial mounds.



All the mounds of Diagram No. 1 are on a flat, low ridge, about 40 feet above high-water of the Ohio River.

This group of four mounds (Diagram No. 2) was visited with the intention of excavating No. 3, but it was not possible to get men to walk so far. My attention was called to this group of mounds by Mr. Richardson, of Uniontown, who had knowledge of the opening of mound No. 3 for the purpose of interring a

* The measurements above are from base to base of the mounds and not from center to center.

negro man, who desired to be buried there. In digging the grave, skeletons were discovered and also three or four earthen vessels. These mounds are on the lands of Mr. Burbank, about 1½ miles west of the group on Diagram No. 1. No examination was made of the country lying immediately between these groups.

The Lindsay mound.—This is an isolated mound, there being no other nearer than half a mile. It is situated on the low hills which form the margin of the flat lands on Buffalo Creek, a tributary of Cypress Creek, of the Ohio, about four miles in the rear of Raleigh, Union County, Kentucky. It terminates a low point of a low ridge and is about 33 feet in diameter. It was examined in 1854 and many skeletons discovered, with specimens of pottery; with three skulls. The latter were forwarded to the Smithsonian Institution at that time. This examination having revealed the character of the mound, I determined to explore it thoroughly. The work was begun on the west side (the lowest) and the whole examined by trenches from 4 to 6 feet deep.

On the west side bodies were found covered with six feet of earth, forming there about five separate layers. The bones of the lowest layer were so tender that they could not be removed, and deeper digging was not made. It is therefore not known whether the lowest bodies in this mound were reached. It would appear that the general plan of burial was to scrape the surface free from all vegetable matter, and deposit the body on its back, with the head turned to the left side. The bodies at the bottom of the heap, so far as could be ascertained by the examination, were buried without weapons, tools, or burial urns, (pots.) No traces of vegetable matter could be found in the fine siliceous earth with which these deeply-buried bodies were covered. To the depth of three feet from the surface, some of the bodies had with them burial urns. They were found near the bodies of infants and young persons, and it was with difficulty a single fragment of the bones could be procured by caving in the face of the digging. The bones of old and adult persons were well preserved in the siliceous loam, but very imperfectly in clay. Three or four tiers of skeletons, of later burials, were covered with clay. It is probable that as many as three hundred bodies, infant and adult, were buried in this mound. All the flints and other works of art found entire were packed in the four barrels and box No. 2 sent. The pressure of the roots of the trees growing upon and around the mound had broken many of the burial urns. Several of these, of unusual form, were sent without any attempt at restoration. No bodies were buried exactly in or near the center of the elevation, but they appear to have been arranged in a circle, head inward for the first layer, and extended toward the margin by an additional circle or more of bodies. Adults and children were buried together, the latter lying between the former. Toward the margin of this mound on the east side, there was some irregularity in the burials. Three bodies were found head outward, three or four lying nearly at right angles

to the radii of the circle. No urns were found with any of these irregular bodies. Some of them lay in clay were too tender for removal.

A poplar tree was felled ten years ago at the margin of this mound, of which the rings, counted at the time, indicated an age of two hundred and forty-nine years. A root of this tree, over one foot in diameter, ran nearly across the mound. At one point where this root was cut away were found four tiers of bodies under and two above it. Two or three excavations had been made long since into this mound, through one of which the large root passed, showing a greater antiquity than that of the tree. The colored earth showed, in one of these excavations in section, an inverted cone with irregular outline four and a half feet at the surface and one foot wide at the depth of five and a half feet. This hole or evidence of an excavation extended down to the earth of uniform color. At the bottom were found the skull of a female elk, two odd jaws of bears, and a small bundle of deer-bone awls. Three other of these ancient pits contained bodies. The direction of the heads was irregular, not conforming to the common method of burials. With one body flint weapons were found; this was at a depth of five and a half feet. The parcel of flints in box 2, the deer-horn tips, and the fragment of elk-horn were found with this body. The principal works of art obtained were the specimens of pottery.

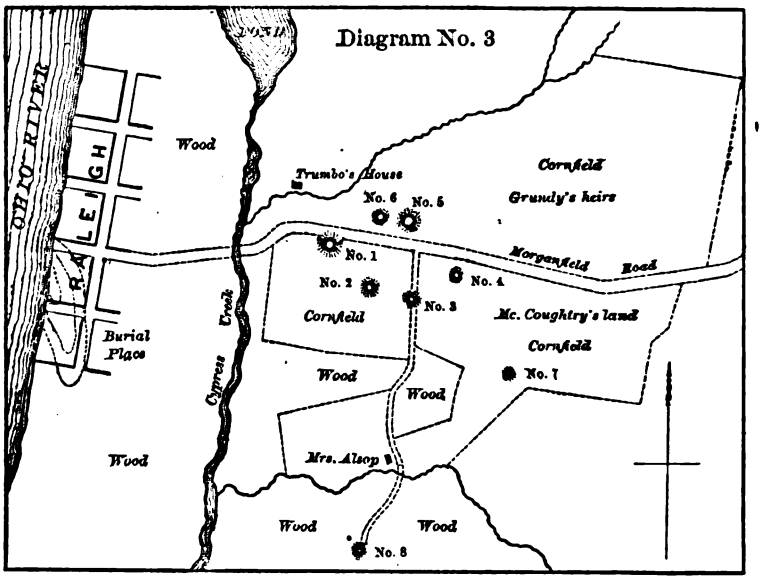
On the northeast side of the mound the original soil was reached. On the west side it was not met with at a depth of 6½ feet. The entire mound was dug away except at the margin, and where large trees interfered with the work on the northwest side. The first burials either were made by those who had no works of art, or no superstition or usage requiring such articles to be buried with their dead. No bark or vegeable substance was used to cover and protect the bodies, or else they have entirely disappeared.

The character of the earth forming the whole mound, except at the northeast side, is such that it may be traced to a considerable excavation, distant one hundred and fifty yards toward the southwest. The mound was evidently formed by burials made on a cleanly-scraped surface, on which the body was laid, and then covered with the yellow sandy loam from the pit just alluded to.

The burials to the depth of three feet from the surface appear to have been made in the same form and manner as those below, and the addition of the burial vases distinctly marks either a change of art or superstition. The irregular burials are those made by excavation in the mound, and filling the hole over the bodies. A critical examination of these holes satisfied me that no sharp tool was used in making them. Sticks and the hands appear to have been the implements employed.

In the Lindsay mound are three kinds of burial: those without works of art; those with works of art bodies laid on the surface; and those of the deep excavations, which contain badly preserved bones, and

cut through the ancient surface. The graves dug were filled with mixed and discolored earth. Such a mound as the Lindsay mound I term a common burial-place, or a burial-place of the common people.



There are other mounds somewhat differing from the preceding and evidently for a different use. Of these, No. 1, Diagram No. 3, is an example. This mound is about 125 feet in diameter, and from 9 to 10 feet high. It was examined by digging a ditch 45 feet long, 6 feet wide, and 8 feet deep; beginning about 10 feet from the southeast side, curving a little toward the north to avoid a large tree, and at the middle bearing under in various directions to obtain any articles that might have been buried near the center of the structure. Here I found nothing. I learned after my work was done that many years ago this mound had been examined and some articles obtained at a center opening. Although I added nothing to the collection, I ascertained that this mound was of a different construction, and evidently for a very different purpose from that of the burial mounds.

The excavation exhibits a central nucleus of sand, about two feet high and twenty feet in diameter. This was built upon, preserving the rounded form, the layers of earth thicker in the center, and gradually becoming thinner toward the margin, until the work was completed. The earth over the sandy center appears to have been deposited in loads of about half a bushel each of the soil and subsoil of the surrounding fields, distinctly marked in sections into mottled layers; such a structure as would be made if the soil and subsoil were excavated from 15 to 18 inches deep around the mound. Near the margin of the mound was found a pit about three feet in diameter, extending into the subsoil about two feet, filled with alternate layers of earth and ashes. The ap-

pearance was such as would be presented if a pit were dug of the dimensions stated, a considerable amount of wood burned in it, after a long interval of time (leaves and earth having accumulated half a foot thick) a large fire again made and long continued, producing an inch thickness of ashes, the fire suffered to burn out and no coals left, thus adding successive layers of ashes and earth until the hole was full. The fires must have been repeated seven or eight times, lining the entire hole with ashes, and gradually filling the excavation.

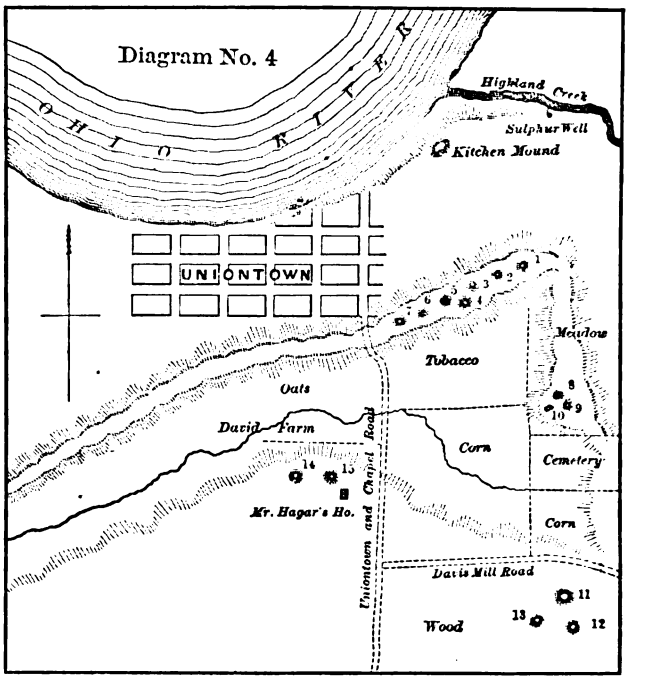
No. 8, Diagram 3, was next examined. This is a low mound, 45 feet in diameter, formed of sandy loam, very uniform in quality and color. Rounded pebbles of the same character and general appearance as those on the shore of the Ohio, one and a quarter mile distant, were found buried in groups of two, three, five, and seven. Attracted by this grouping of the pebbles a large amount of labor was bestowed on this mound. It had evidently not been made for a burial-place.

No. 3 appearing of the right form, and not being on cultivated land liable to be injured by the excavated materials, was more than half dug over by my party to a depth of three feet. It yielded broken pottery, rough fragments of flint, burnt surfaces from one to three feet deep, but nothing worth preserving.

By permission of the proprietor, and promised payment for the corn destroyed, I opened mound No. 4. This, like the Lindsay mound, proved to be a common burial-place. Pottery and broken pots strewed the ground. The top of the mound had been reduced by cultivation. Some of the bodies had been half cut away by the plow, and most of the burial vases broken. I dug this mound entirely over. The bones found were very tender. With one skeleton was a parcel of paint, a large double-pointed flint, and a small one; an arrow-head, a small piece of specular (?) iron ore from Missouri or Arkansas, and some small flints. The broken pot was a large one, placed near the shoulder on the left arm. Only a few of the burial urns escaped the plow, roots, frost, and the spades of my men. I sent in the box (marked McCoughtry mound on some of the parcels) every thing supposed to be of interest. My own experience teaches me that clay or tough, loamy soil is not as good a material to preserve the bones and pottery as the fine siliceous earth. (Loess of Dr. D. D. Owen. See Kentucky Reports.)

I next began operations on the first range of low hills immediately in the rear of Uniontown, nearly south of the mouth of Highland Creek, Diagram No 4. This group consists of seven mounds, three large and four small ones. Southeast lies a group of three, and south of these another group of three; Nos. 14 and 15 are about fifty yards apart, 40 feet diameter, 8 to 10 feet high, about the size of Nos. 3, 4, and 5. Nos. 1, 2, 6, 7, 8, 9, 10, 11, 12, and 13 are low mounds, varying in size from 25 feet to 60 feet diameter, and from 3 to 4 feet in height. Near the mouth of Highland Creek is a Kitchen mound. There are a few Indian burials along the line of the river bank. These are covered with

clay, evidently subjected to the action of fire. Mound No. 1 was examined by a ditch from east to west, 4 feet deep, 30 feet long. This ditch cut out the center of the mound and reached the subsoil. Some



small fragments of pottery and a few irregular chips of flint, and the character of the material forming the structure, were the only evidences of its artificial nature.

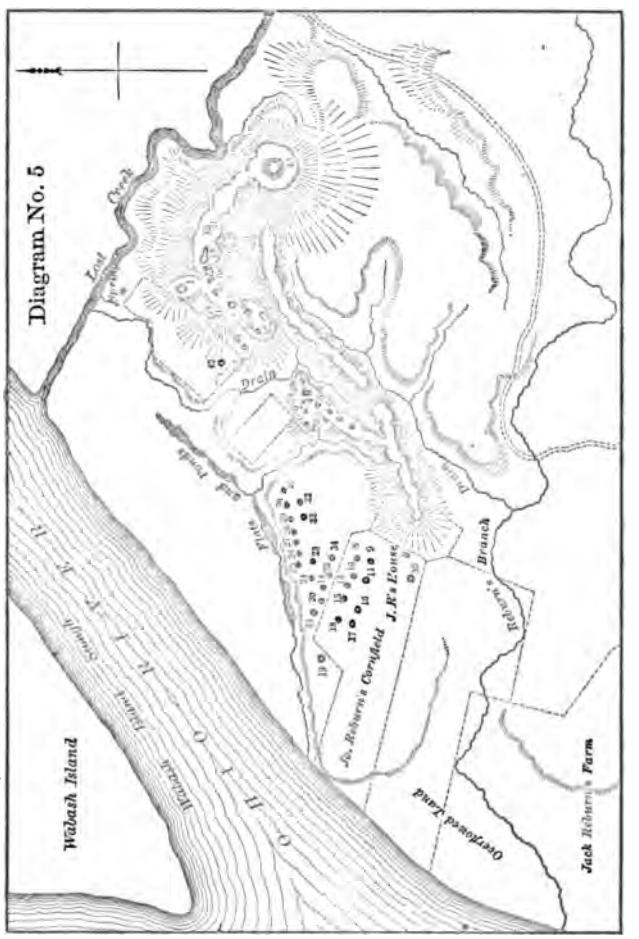
Mound No. 5, one of the three large ones of this group, we dug away about one-third. On the southeast side several skeletons were found, at a depth of about 3½ feet; two or three skulls without bodies, and some parcels of bones, evidently dismembered before burial. All these interments appear to have been secondary. This mound is composed of materials differing in character, and resembles mound No. 1, (Diagram No. 3.)

Mounds Nos. 9, 10, and 11, on examination were found to be of clay, and therefore, as already explained, a detailed investigation was not made. Mound 14 had been dug into for an ice-house vault. Mr. J. W. Hagar, son of the party who built the ice-house, and who aided in the excavation, made the following statement in reference to this mound:

"At a depth of 6½ feet, near the center, we found the body of a man, buried in a sitting position. Near his head, on the west side, was found a variety of articles—a pointed flint-arrow or spear-head, from 10 to 12 inches long, 3½ to 4 inches wide, beautifully made; it was not a double-pointed flint, but had a groove for fastening; three circular stones, half an inch thick, an inch and a half in diameter, concave on both sides, a

hrough the center, the margin grooved like a pulley, (we called pulley stones,) with about five small perforations from the center margin of the pulley, in the direction of radii, to the opening in nter; an article five inches long made of copper nearly in the of an awl, the large end or handle very much oxidized, (probably wooden handle;) a flat stone with holes; an earthen pot broken, its about one gallon; a thin piece of copper one-sixteenth of an hick, irregularly round, covered with some woven fabric not unne linen. The diameter of the disk of copper was about three ."

ox No. 2 is a copper disk, which was found in a low mound with two pieces similar in form and size, by Mr. McKenny, who states that ree disks appeared to be the ends and middle of a "spool," which found had on it what appeared to be the remains of a fine twine



rse thread. The mound from which this copper article was taken low one, 10 feet in diameter. Being in a field, it was soon plowed

down to its foundation, which was a circular pavement of stones. These being in the way, they were dug out and removed. On the north side of the pavement was found a heap of ashes, and lying across the pavement, nearly in the center of it, the bones of an adult. No other work of art than the disks was found. The earth removed from the center was about 18 inches deep.

The mounds near Uniontown not proving of sufficient interest for my present purpose, I proceeded to examine a locality near the mouth of Lost Creek, opposite Wabash Island, Union County, Kentucky. Diagram No. 5 presents a rough sketch of this remarkable collection of groups of mounds. When I first examined this series of mounds I noted them roughly on a sketch. As my knowledge of their number increased, and my book being too small to map them on a scale, I proceeded to measure the distances between the several mounds, and to estimate their height. I began on the 8th mound and made the following measurements and estimates, from center to center of mounds:

Copy of notes.

8. Mound in field, 5½ feet high, 90 feet diameter; distance between 8 and 10, 354 feet; distance from 10 to 12, 54 feet.

12. Diameter 33 feet.

In the following notes the distances given is that between two mounds, as for example between 10 and 13:

10 and 13, distance, 54 feet; 10 is 3 feet high.

12 and 13, distance, 84 feet; height of 12 and 13, 4 feet; 13 is 40 feet diameter.

13 and 15, distance, 120 feet.

13 and 16, distance, 159 feet; 15, 42 feet diameter; 16 is 54 feet diameter.

16 and 17, distance, 51 feet; diameter of 17, 36 feet.

17 and 18, distance, 81 feet; diameter of 18, 33 feet.

18 and 19, distance, 165 feet.

13 and 14, distance, 80 feet; diameter of 14, 40 feet; 18 is 3 feet high.

14 and 20, distance, 54 feet; diameter of 20 is 74 feet; height of 20, 7 feet.

20 and 21, distance, 71 feet; diameter of 21, 33 feet; 3 feet high.

14 and 22, distance, 75 feet; diameter of 22, 48 feet; 3 feet high.

22 and 23, distance, 114 feet; diameter of 23, 72 feet; 3 feet high.

23 and 24, distance, 69 feet; diameter of 24, 66 feet; 8 feet high.

24 and 25, distance, 75 feet.

25 and 26, distance, 75 feet; mounds 25, 26, and 27 are 3 feet high; diameter of mound 26, 36 feet.

26 and 27, distance, 100 feet; diameter of 27 and 28, 40 feet.

28 and 29, distance, 50 feet; diameter 33 feet; height, 3 feet.

29 and 30, distance, 63 feet; diameter 33 feet; height, 3 feet.

30 and 31, distance, 75 feet; diameter 33 feet; height, 3 feet.

31 and 32, distance, 45 feet; diameter 20 feet; height, 2 feet.

32 and 33, distance, 75 feet; diameter 33 feet; height, 5 feet.

33 and 34, distance, 100 feet; diameter 33 feet; height, 5 feet.

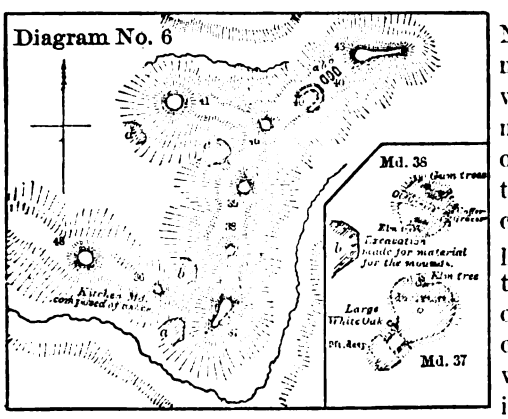
35 from 8, distance, 800 feet; diameter 80 feet; height, 6 feet.

Nos. 2, 3, 4, 5, 6, 7, &c., are quite close together on the back of a sharp, narrow ridge. No. 4 is an oblong, rectangular mound, about 30 feet long, 12 feet wide on top, 8 to 10 feet high. Mounds 5, 6, and 7 have been used for burial places within the last few months. Mounds

22, 23, and 24 were partially examined. They did not prove to be common burial-places, and were abandoned for the present. These mounds are formed of sand, different from that found in the hills near by and that used for the covering of bodies in the common burial-places. The material used appears to have been taken from the drifts of fine sand washed by the Ohio River in to the overflowed land.

The operations were then carried on in mounds 37, 38, and 46. I was attracted to mound 37 by stones standing near the center of it. This is the only mound examined by me in which stones were used to form any portion. No. 37 is an oblong or pear-shaped mound, the largest part being 65 feet diameter; the neck, 42 feet long. The greatest length 107 feet; greatest width, 65 feet. The scale of Diagram No. 5 is too small to exhibit the form or arrangement of the group to which 37 belongs. It will be better seen on Diagram No. 6.

Diagram No. 6



Mound No. 37 (Diagram No. 6) was opened on the northwest side, at a point which appeared to be the margin of the artificial part of the hill. The discoloration from the leaves and decomposed vegetable matter penetrated the earth about three feet deep. At the depth of two feet bodies were encountered. The earth was well thrown back and an opening 14 feet long and 5 feet deep was made, giving a face on the side of the ditch toward the mound 14 feet long by 5 feet deep. The bottom of the ditch appeared to be the subsoil of the country, a stiff clay. By digging into this clay it was found to be very stiff, and full of a whitish mold not unlike that found within the skulls, and at the bottom of some of the burial urns or pots. During the progress of the work this clay was found to cover all the circular part of the mound removed. (See Diagram No. 6, mound 37.) In contact with the clay 5½ feet deep the bones were very tender. When near the center of the mound I had an opening made into the supposed subsoil, and found it to be a coat of stiff moldy clay covering bodies buried one above another to the depth of 12½ feet. At the base of the clay, 6 feet deep, was found an irregular pavement of limestone, evidently obtained from an outcrop of the "Carthage limestone" occurring half a mile to the north. The same limestone forms the bed of the Ohio River between the Kentucky shore and the head of Wabash Island, one mile distant.

The margin of the mound at 6 feet below the summit and on a line with the pavement was composed principally of small pieces of the same

rock. The pieces composing the pavement varied in size from 20 to 150 pounds weight. Many of the bodies found at the base of the clay appeared to have been covered by slabs of the stone forming the pavement set up slanting toward the body with the ends of opposite stones resting against each other, thus roofing the body in.

The bodies beneath the clay did not appear to have been buried in the order generally observed in the mounds heretofore examined. Beneath the clay bed, to the depth of 6 feet, the bodies were evidently buried by covering, after having been laid upon a cleaned surface, with the sandy earth obtained from some of the banks, marked *a*, *b*, *c*. (Diagram No. 6.)

A large excavation was made below the clay and pavement and many bodies removed; the bones were quite tender. No works of art were found. The hole was filled up and the work carried across the mound to the depth of the mouldy clay.

I was particularly interested in the fact that in this mound there was an absence of all works of art in the deep burials, and less regularity and system in the manner of arranging the bodies than that observed in the later burials or the urn-burying tribes. As in the Lindsay mound the deeper-placed bodies did not invariably lie on the left side, and the head was sometimes on one side, sometimes on the other, sometimes thrown forward or backward. The mouth was frequently open, retaining a horrible expression. No fragment of pottery or flint was found under the clay layer in mound 37. Two or three of the skulls of the deep burials will be found in barrel No. 5 shipped from Uniontown, Kentucky.

The burials above the clay layer of this mound conform generally to the plan of those of the Lindsay mound: heads inward, lying on the left side, &c. There do not appear to have been so many pots buried as there were bodies. The use of the burial urns seems to have been more frequent at the burials in the Lindsay and McCoughtery mounds than in this one. Some of the last bodies placed in this mound with an urn were very slightly covered. Two bodies which were found with urns were covered from the head to the hips with rough stone similar in arrangement to those bodies alluded to which were found under the clay layer of this mound. A few vases were found entire, but the greater number were broken. Some appeared to have been broken before they were placed with the dead body about to be covered.

With some of the bodies, about 3 feet below the surface, there occurred a parcel of small, long, round bones. In one of these parcels was a needle made of bone and an ornament made of the shell of an unio, also a pair of unio shell drops. The hurry and discomfort of the work forbid a very careful examination of the articles, or an attempt to sketch any of them. A single double-pointed flint was the only article of stone found in the mound, and this not in any apparent connection with a body. It appeared to have been dropped upon

the top of the mound, and was found not deeper than six inches below the surface. In working southwardly, toward the white-oak, in mound 37, the end of a discolored line of earth, 3 feet wide, was encountered. This was carefully followed 5 feet deep to a skeleton, the head lying toward the north, feet south. This was evidently an interment made in an excavated pit. Extreme caution was used in removing this body. The head was found entire. Near the head, in the position of the ears, were found the two copper bells packed in box No. 3.

In making the original excavation for the reception of this body, at least three bodies, or parts of bodies, had been removed, and this body placed as deep as the third or fourth tier of layers, the head resting on the layer of moldy clay, so frequently referred to. There were three or four other burials made by excavating in this mound, but as nothing worthy of note was found with them they require no special description. The bones removed by digging the graves referred to appear to have been carelessly thrown into the grave over the newly buried body, but never in immediate contact with it.

A considerable excavation was made into the elongated neck of this mound. Urn burials extended down about 5 feet, regularly disposed. The digging was carried 9 feet in depth, and great irregularity was observed. At the depth of 5½ feet the body of a youth was found. The skull and long bones were sent in barrel 6. This body may be known by the base of a deer's horn packed with the skull. The whole horn was buried just above the face, the head slightly elevated, directed outward, and toward the falling land or slope. Parcels of bones disconnected were found buried in this part of the mound, in excavations which cut through former burials; heads disconnected from bodies, loose bones, &c. With one of the regular covered burials, about 3 feet deep, were found some ornaments made of panther's (?) teeth. Two or three feet distant from this body was found a parcel, in discolored earth, containing parts of a jaw with feline teeth and some pieces of vertebra of an unknown animal. The number of relics obtained was very small, when the amount of work done in the examination is considered. A considerable number of long bones were preserved and packed in barrel No. 5, also one entire vertebral column. The material among these bodies is the same as that in the Lindsay mound, but generally the bones are not as well preserved.

There are several mounds in this group of grander proportions than No. 37, which would doubtless prove of great interest if thoroughly examined—300 or 400 cubic yards carefully removed from some of these mounds would probably yield many valuable and interesting results.

In the group of mounds 2, 3, 4, 5, 6, and 7, (Diagram 5,) the mounds 5 and 6 are the site of a recent burial-place.

Mound No. 36 (Diagram No. 6) was examined by a ditch 5 feet wide and 18 feet long, extending from the south side northwardly beyond

the center. It proved to have been a kitchen, being composed principally of ashes of unio shells, broken pottery, bones of animals, &c. A small ax or skin-dressing chisel was found at the surface. The fragments of pottery appeared to be parts of vessels, differing in form from those found in the mounds. The vessels were larger, thicker, and generally parts of shallow dishes. The fragments of one vessel, resembling these, was found in mound 38, and one in the neck of 37. These fragments are among the articles from these mounds sent to the Smithsonian.

Mound 38 (Diagram No. 6) was thoroughly examined. It was a low mound, about 4 feet high and 45 feet in diameter. Figure 38 (*a*) (Diagram 6) shows the amount of surface uncovered in this mound.

It appeared to have been completely covered by two layers of the bodies of the vase-burying people. On the southeast side were found three of the stone burial-places, of a later period than the vase burials, some of the vases and bodies with which they were buried having been removed to give place for these later structures. A trench from 4 to 6 feet wide had been worked over through the center of the mound, from the stone boxes toward the northwest, disturbing the bodies.

Sometime this later digging cut a previously buried body in twain, leaving the head and feet in place, the more recent burial having been made in a line nearly at right angles with the body partially removed. This disturbance rendered the work very difficult. While tracing one body longitudinally another was encountered lying at right angles, either above, below, or cutting through the body being traced.

In the undisturbed part of mound 38 the bodies observed the arrangement referred to at the Lindsay mound.

It was in the disturbed part of mound No. 38 that the two pipes were found. I was careful that the decomposed portions of the stone on one of the pipes should be preserved, for it may possibly give some hint as to the length of time these articles have been buried. A small conical-shaped article was found with the body, and also the black stone with holes through it. I have seen this kind of an instrument used by the Pah-Utes, of Southeastern Nevada, for giving uniform size to their bow-strings.

A few burial urns with seven ears were found in No. 38. I do not recollect that any of this form were found in any other mound. The bones in mound 38 were not so firm as those found in other mounds. Many bodies were disinterred of which bones were sufficiently firm to pack up. Barrel No. 6 contains the most perfect skulls from mound 38. A considerable number of long bones from this mound will be found in barrel No. 7. I omitted to mention an article found in mound 37, circular in form, apparently formed of bone.

With the exception of the copper bells all the articles found and forwarded to the Institution are of the rudest form and evidently the product of a primitive people. The fact of the bells having been found in

a dug burial-place indicates a later burial and a race of different habits. I have no hypothesis as to the time these mounds were made. They do not appear to have been constructed by a warlike race. Only two bodies, of about 1,000, that I have encountered seem to have been buried with anything like arms.

To one who has made a study of the mound-builders, the groups of mounds (Diagram 5) would offer great inducements for investigation.

I have observed some remarkable facts in reference to the mounds, but they are too few in number and too disconnected to form a good foundation for a true theory of the life and condition of the mound-builders of this district. A careful examination of the cranica by a competent person will perhaps throw some light on the intellectual condition of this people.

This report is hastily written from my notes made in the field. It may serve, however, as part of the basis of a regular work, to be prepared by some properly qualified person who may have the results of this investigation before him. In my examination of the mounds I was compelled to pack away the articles collected as fast as they came to hand, the sun affecting the bones injuriously.

To any one who may continue this work I would recommend the months of September and October, with tents, and all such conveniences as will enable the party to make full notes. Let the laborers be hired for the trip, and informed as to what they are to do and how they are to do it. Many crania and burial-vases in good condition when reached, were broken by the haste, awkwardness, or carelessness of the men. With proper preparation and careful, industrious laborers, important results may be expected.

Probably many of the articles, especially the bones sent, will be thrown out as useless. Some of the bones were packed up and forwarded to show how much they were decayed. Many long bones were sent to determine the stature of these people. It was a common remark during the work that the bones were of very large size. I think the men were generally under size—not so large as the men of this age.

A considerable number of ribs were taken from the Lindsay mound under the impression that they indicated bodies less round than the present races. This question I am not able to answer; but I have, on much reflection, concluded that the peculiar form of these ribs is in a great measure due to the pressure of the earth on the bodies.

In unpacking the bones sent I would recommend that each parcel as it is opened be washed and dipped in weak glue, when dry, that each bone, intended for preservation, receive a thin coat of the best copal varnish. This was the treatment I gave to the bones sent to the Institution in 1856, taken from the Robinson mound.

SKETCH OF ANCIENT EARTHWORKS ON THE UPPER MISSOURI.

By A. Barrandt, C. E., *of Sioux City.*

The archæological remains of the Upper Missouri, from the mouth of the Yellowstone, in a southeasterly direction as far down as Bonhomme Island below Fort Randall, exhibit a progressive change of structure and outline from the most simple to the most complicated. During my stay in that region, 1869–'70, I had occasion to visit several of those ancient fortifications. Among the most important and well preserved is one existing about nine miles south-southeast of the Missouri and within half a mile of Clark's Creek, Dakota. The main work is in the form of a parallelogram, three hundred and forty feet long, one hundred and ninety feet wide, and twenty and twenty-five feet high; the walls are, on an average, seven feet thick at the summit. There are two openings, one facing the west, twenty-four feet wide, and the other facing south, only nine feet wide. The space inside is now full of cotton-wood and ash trees. Several large blocks of sandstone, roughly hewn, were found, but the walls and a ruined portion of what appeared to be the remains of a smaller inclosure, were of calcined clay, changed by burning into a brick color. Following the banks of the creek for half a mile, we came to the remains of a wall of about five feet in width and in some places attaining the height of from three to five feet. We traced the wall for about four hundred yards; it runs for about one hundred and fifty yards from east to west, then turning at right angles from north to south, the end of which reaches the edge of a deep and precipitous ravine, beyond which we could not find any traces of ruins.

About two hundred and fifty miles up the Bighorn River we found also another large mass of ruins, where was probably the site of a large mound city, but none are now existing; they have all crumbled away, and from a large oak tree that we felled, I found that they must have occupied this spot at least six hundred years ago, as the tree grew on the remains of what had been probably the largest mound. We found that these mounds had, for the most part, been constructed of turf and adobe or sun-dried bricks of inferior manufacture, which accounts for their decay.

Another curious spot that I visited was what the Indians of the present time call Matou-tipee, (Bear-house.) It is a large mound constructed of calcinated clay, which by burning was changed into a brick color. It is situated near Grand River on a high elevation of land; it is encircled by the remains of a wall; one portion running from east to west and then down a hollow; turning at a right angle it runs from north to

south, the ends reaching the banks of the creek. Within the area of these remains of gigantic walls we found several small mounds of from twenty to forty feet in circumference, and from ten to fifteen feet high.

Further up the Yellowstone I found the remains of an ancient city of mounds. It is situated about one hundred and forty miles from the mouth of that river, on a bluff of about one hundred and eighty feet in height. It seems to have been regularly laid out. The streets are regular, and the mounds equidistant from each other. In the southeast quarter of this city, on the widest of the streets, is one of colossal dimensions, sixty-three feet in diameter at the summit, and twenty-seven feet high.

We could not find any opening in this mound, but succeeded by digging into several of the smaller ones to gather remains of some sun-dried pottery; and in one we also found several arrow-heads of stone, fragments of flint, &c. I counted these mounds, and found eighty-seven in good state of preservation, and about sixty-three in ruins. I am satisfied that the remains of the elongated mounds, which are found always on the outskirts of a city, were designed and used for fortifications, though I have not been able to determine if there were any ditches around them. Again, on the banks of the Moreau river, a few miles from its mouth, we discovered another of the mound cities, containing about two hundred mounds, and a number of the elongated ones, which form a regular line of outworks, each wing reaching the bank of the river. Again, about two and a half miles further back to the north upon an elevation of the ground there is a group of the largest mounds I have ever seen. They are built very near together, and are perfect in their form. There are no ditches at their base, and they are wanting in other appearance of fortifications. Yet I believe them to have been used as forts, and that they were placed here to guard the approaches to the town from this direction.

There is still another group of mounds located on the banks of the Great Cheyenne; these resemble those last described—not so large, but more in number.

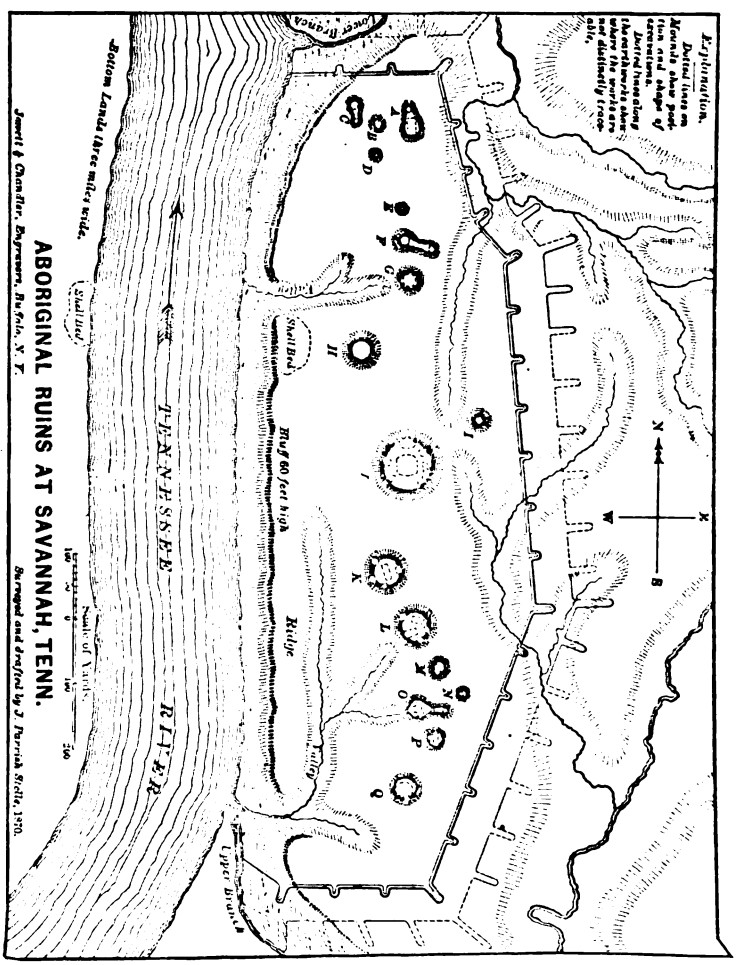
On Bonhomme Island there are also remains of fortifications, which are described in Lewis and Clarke's journal of their expedition up the Missouri, 1804–'5–'6.

This hasty sketch of some of the ancient remains in the Missouri Valley, though the result of the observations of two years, is principally drawn from the hasty entries in a diary; therefore no pretensions are made to minute exactness. As, however, the preservation of a record of the sites of the ancient remains, and every fact connected with it, is important to the student of archæology, this sketch, brief and imperfect as it is, may afford some data of interest in regard to the character of the race of men who once thickly peopled this country.

ACCOUNT OF ABORIGINAL RUINS AT SAVANNAH, TENNESSEE.

By J. Parish Stelle.

These ruins occupy high rolling ground, on the east side of Tennessee River, immediately on the west edge of the town of Savannah, Tennessee. North and south they measure, from outer earth-works to outer earth-works, thirteen hundred and eighty-five yards, and east and west, five hundred and fifty yards. The inner line of earth-works is distinctly traceable, and consists of an embankment thrown up inside from a deep trench, twelve or fourteen feet in width. At every eighty yards there is a redoubt, each one extending outward twenty yards, excepting those at the angles, which project thirty.



The outer line of earth-works appears to have been much lighter. At some points it is still visible, while at others, especially on cultivated grounds, it has entirely disappeared. In the diagram the obliterated parts are represented by dotted lines, and the distinct portions by continuous lines. The outer works are fifty-five yards from the inner, and parallel with them. They also have regular redoubts eighty yards apart; but the redoubts are longer than those of the inner works, measuring forty yards along the line, and fifty-five yards at the angles. The two lines are so arranged that the redoubts of one generally alternate with those of the other.

The earth in which these trenches have been dug is a tough red clay, intermixed with gravel, exceedingly hard to excavate. In fact, the entire elevation upon which the ruins lie is composed of the same material, down almost to low-water mark of the river, where a deposit of limestone begins.

The relative position of the mounds have been located on the diagram by careful measurement.

Mound A: Ten feet high, forty yards east and west, and sixty yards north and south. I made a large excavation in the highest part of it, going down in shape somewhat as shown by the dotted line. At the depth of a foot and a half we came upon a human skeleton, lying on its back, with the head to the south. The bones were so decayed that but few could be taken out. At the left side of the head was a vase, containing the remains of a shell. The root of a tree had grown against and broken the vase, but I took out all that could be found. At the right of the skeleton, about where the hand should have been, if the arm lay at the side, were found three flint implements—knives, I suppose—and a small polished stone that had probably been used for painting purposes. Nothing more was found in this mound. We dug down to the solid earth in two places, as shown by the dotted lines. The mound was composed of a soft alluvial soil, evidently brought from the river bottom, about two hundred yards distant, and down a steep hill.

Mound B: A small one, into which we made a large opening in the center, and at one foot down obtained a stone implement, which was the only article found. The composition of this mound was the same as that of A.

Mound C: Double mound, four feet high. Into this we went down to solid earth in two places, but found nothing, except some bits of charcoal and other evidences of there having been fire at several points. It was made up of alluvial soil, the same as A.

Mound D: Has a house upon it, and therefore could not be opened.

Mound E: Small mound in the garden, with a large tree upon it. I did not open it.

Mound F: Double mound, seventy yards long, forty yards wide at widest point, and twelve feet high. We dug down to solid ground by two large excavations started at the highest points. Within three feet

of the surface, in the excavation, fragments of pottery utensils were found. Nothing further was discovered. These mounds, unlike the preceding, were composed of the tough clay and gravel of the ridge upon which they stood. A depression near at hand showed where the material had been obtained.

Mound G: Forty-five yards in diameter at base, and twelve feet high. Two large white-oak (*Quercus alba*) trees were upon it. In one, which had been cut down, two hundred and fifteen rings were counted, making it two hundred and fifteen years old. We dug a large circular excavation in the center on the top. The earth at the surface gave indications of having been intensely heated. At two feet down we came upon a human skeleton lying on its back, with the hands at the sides, and the head toward the east; the bones badly decayed. At three and a half feet we found another skeleton, lying precisely the same as the first, and immediately under it. At five feet we came to loose stones lying upon one another, and rounded up mound-shaped, which we removed, to the amount of several tons, when the solid earth was reached, and a skeleton was found lying exactly as the others, but further east, the feet of this one being immediately under the heads of the other two. The stones seemed to have been thrown directly upon the body; consequently most of the bones were more or less broken. The skull was crushed entirely flat. At the left side of the head were found three copper relics, lying just as I have tied them together. The string still to be seen in one of them is made, I think, from the bark of papaw, (*Asimina triloba*, Dunal,) a circumstance worthy of note, as it proves that material to be almost imperishable. Modern Indians used it extensively for strings and ropes, and I can recollect when our southern and western people did the same. It was prepared by peeling the bark from the trees when the sap was up, and sinking it under water, to remain several weeks, to "rot," as it was called. When taken out the inner separated from the outer bark, and split up into very thin sheets. It was these sheets that were used, and after having gone through this process they were much stronger than the entire bark was before. I send you a slip of "rotted papaw bark." Immediately upon the breast of the third skeleton was found the fragments of a shell ornament. Nothing further was discovered in "G," though we made careful and extensive search. The composition of the mound, aside from the stones already mentioned, was light surface soil, which seemed to have been scraped up from the high lands.

Mound H: A large mound, ten feet high. It is under cultivation, and therefore cannot be opened before autumn.

Mound I: Has a house upon it, and therefore no examination could be made.

Mound J: Is the largest mound in the group. It is over one hundred yards in diameter at the base, thirty feet high, and perfectly level on the top. We rigged a windlass, and sunk an eight-foot shaft in the

center, down to the solid earth, but found nothing, except now and then a broken flint or fragment of pottery. We then dug in the sides, permitting the earth to fall into the shaft, until we had a large excavation, in the shape represented on the diagram, but still found nothing. We next made excavations twelve feet deep, at various points, but discovered nothing in any of them, except in one. Here, within a few inches of the surface, we came upon broken fragments of brick, or burned earth, exhibiting some kind of molded work. They were in considerable quantities, and looked as if they might originally have been hollow columns. If solid columns, the fragments would certainly have been larger; the specimens sent are of average size. Immediately under these, about one foot below the surface, was what might be styled a tile floor, perfectly level and smooth. We removed the earth, and found it to be somewhat crescent-shaped, covering a space of forty-four feet one way, and sixteen the other. How much larger it had been we could not learn, for roots had grown into it and broken it up. The tiling, if such it can be called, was about an inch thick, and seemed to have been made by spreading tempered clay smoothly upon a leveled space of earth and then hardening by means of fire built on top of it. There were no seams to indicate that it had been made otherwise and laid down in sections. Nothing else was found, except some charcoal around the edges.

Like F, this large central mound was composed of tough clay and gravel, making it very hard to dig. Within a short distance were three great depressions, from which the earth of which it was formed had evidently been taken.

Mound K: A low mound, eighty yards in diameter at the base. We opened it in various places, as shown in the drawing. Six feet in the center brought us to the bottom, eighteen inches of which was composed of a soft, black earth, in which were found bones, deer horns, shells, fragments of pottery, &c. In this deposit we also found two stone implements, probably used for pounding corn, opening shell-fish, or something of the kind.

Mound L is similar to K in every respect. In addition to the usual *melange* of black earth, bones, shells, &c., we found one pounder and two pieces of red stone, which, I suppose, had been used for painting. We also found one flint knife. Persons not familiar with such relics might mistake these knives for arrow or spear heads, from which they differ in not having notches worked in the large end for the purpose of attaching them to a shaft.

Mound M: Thirty yards across at base, and five feet high. At two feet down we came upon a fossil shell and a beautifully-finished little stone; I call it a paint mortar. There was no sign of bones, which leads to the supposition that these articles were simply buried there for safe-keeping. At four feet down we found a large and splendid stone implement. It was lying near one side of the mound, and appeared to

have been lost there, as there were no visible marks of anything further. Nothing more was found in this mound. The composition, light soil, as usual, shows that it had been gathered from the surface.

Mound N: Fifteen yards across, and three feet high. Two feet down we found a broken stone implement, which was the only article obtained. The composition of the mound was the same as M.

Mound O: A double mound, forty by seventy yards at base of largest end, and eight feet high. We excavated at three points, and found two to be of no interest whatever. The third one, at the large end of the mound, proved otherwise. We started down through red and crumbly earth, indicating that it had been exposed to high heat. The deeper we went the stronger the indications of fire became, until finally, when three feet below the surface, we came to a bed of charcoal, or rather what proved to be a charred log lying horizontally. We opened the mound thoroughly, and found that it had three furnaces passing in at the base of the lower side, (the mound is on inclined ground,) and running parallel, about six feet apart, almost entirely through to the base of the higher side; that is, ranging upward through the mound at the angle of the surface of the solid ground upon which the mound stood. They had been formed by first digging trenches into the earth, two feet wide and eighteen inches deep. Over these, rude arches had been thrown, formed of irregular masses of tempered clay, probably sun-dried. Some of these masses we took out entire. They are about as large as a man could handle conveniently, and having been immediately in contact with the fire, are burned very hard.

In the spaces formed between these furnace trenches, and near the center of the mound, were found two small piles of human bones, (one pile in each space,) which seemed to have been thrown together without regard to regularity. I do not think there could have been more than about two skeletons in each pile. They were completely charred by the heat from the furnaces, and consequently were very tender to handle. On drying out they became much harder. From the three main furnace trenches went up a large number of small flues, eight or ten inches in diameter, whose walls had also been formed of tempered clay, and were now burned very hard. At some points they rose directly toward the surface of the mound, while from others they wound and twisted about through it in various directions, all skillfully planned with a view to conveying the heat to all parts of the pile.

Running through the mound horizontally, at different elevations, were large logs still retaining their entire shape, but completely charred. We traced one from end to end, eighteen inches in diameter and twenty-two feet long. The ends showed that they had been burned off to make the piece the desired length, and their great irregularity of outline led me to think that the operation had been performed while the log was yet green, and retained its sap. The burning had evidently been forced by placing dry pieces of wood across the log and keeping

them carefully "chunked up," and the irregularities were due to the different positions of the cross-pieces; the log, in consequence of being green, having immediately ceased to burn when there was no direct contact.

In addition to these charred logs there were a number of upright posts, also charred, which seemed to have been placed in position as the earth had been filled in, to prevent too great a pressure upon the flues. Some of them were more than a foot in diameter and five or six feet long. Their ends presented the same irregular outline as the horizontal pieces. I found one piece of split timber four feet long, eight inches wide, and two inches thick. Its ends showed that it had been broken to its existing length by main force, for, although a solid coal, the splinters were yet perfect.

I saw nothing about any of these timbers that indicated their having been worked by other means than fire, and if there had been anything I would certainly have noticed it, for they were entire, just as they had been placed in the mound, merely large, solid coals. The coal was in as good a state of preservation as if burned but yesterday, as you will see by the specimen sent. Two of our blacksmiths have examined these specimens. Both agree that one kind is chestnut, (*Castanea vesca*, Linn.,) but differ with reference to the other—one claiming that it is poplar, (*Liriodendron tulipifera*, Linn.,) while the other pronounces it our yellow pine, (*Pinus rigida*, Miller.) The two former trees grow abundantly about the locality of the ruins, but the pine has not grown nearer than four or five miles since the country has been known to white people.

Every part of the large end of this mound, from base to top, had been affected by the heat from the furnaces and flues. In fact, it was one huge brick, hard burned near the base, and softer toward the top. The earth seemed to have been thrown up loose; none of it had been tempered except that forming the arch of the furnaces and the walls of the flues. There were no fragments of pottery, or dross, or cinders, or anything else upon which a hypothesis could be based touching the object for which the mound had been used. Ashes in the furnaces, bones, burned earth, and charred timbers, as already mentioned, were the only things found after a most careful and exhaustive examination.

Mound P: This mound, about fifteen yards across and four feet high, was opened by curiosity-seekers two years ago. Report says they found nine copper spools like those taken from G, a copper wedge, and a stone paint mortar, as I call it in default of a better name. After diligent inquiry among the people interested in the digging, I have succeeded in obtaining the "wedge," the mortar, and part of one of the spools. The discoloration in the concaves of the mortar is due to something put into it since it was found—indelible ink, (nitrate of silver,) I think. The markings around the edge were the same when found.

The parties who did the digging assure me that they saw no bones, but I think they must have overlooked them, for on opening the mound

more thoroughly I found fragments of a human skull, but no other bones. These lay near the edge of their opening; hence I conclude that they must have taken the skeleton out. I also found, lower down, three fragments of stone implements. The composition of the mound was surface soil, as usual.

Mound Q: Twenty yards across at base, and nine feet high. At eighteen inches down we came upon a bed of coals and burned earth, evidently where a large fire had been. At three feet, in what appeared to be a deposit of ashes, we found a copper relic; at four feet, lying alone in the yellow earth, a stone implement; at four and a half feet, what seems to be a copper plate attached to a fragment of matting; at six feet, a second stone implement like the first; at eight feet, lying immediately together, three pieces of lead ore; and at nine feet, on the solid earth, a small string of copper beads.

There were no bones or other things in this mound indicating that it had been used as a burial-place. All the articles found, except the copper wheel, lay immediately in the yellow earth, and there were no discolorations in the adjoining soil, which must have been the case had perishable articles been buried with them.

I think you will find the beads are held together by the same imperishable material to be seen in the copper relics found in G.

SHELL BEDS.

There are two extensive shell beds in connection with these ruins, one on each side of the river. That on the eastern side has been under cultivation for years, and lying immediately upon the surface it is not in so good a condition as it would otherwise have been. It covers about half an acre of ground, and is some eighteen inches in thickness. I explored it pretty thoroughly before this season's crop was put in, and in the collection marked "R" you will find the result, together with some of the shells composing the mass.

The bed on the west side of the river was entirely undisturbed until I examined it. It covers a little less than half an acre, is about two feet in thickness, and lies three feet below the surface; that is, the overflows of the river have made a sedimentary deposit upon the shell bed three feet thick. Taking into consideration that this river seldom overflows oftener than once in a year, and sometimes but once in several years, that its waters are not then as muddy as most other rivers at such times, and that being a mountain stream it soon subsides, we can form at least *some* idea of the age of this shell bed. In addition to this, I may say there is now growing upon it a burr-oak tree, (*Quercus macrocarpa*, Michx.,) fully six feet in diameter.

I explored this bed carefully, and you will find an assortment of what I obtained in the collection marked "S," together with specimens of the

shells. The broken pottery was in great abundance, and seems to have been broken vessels thrown away with the shells and other refuse. The same shell-fish are now to be met with in the river, but they do not seem to be in great abundance, judging from what are found along the shore. It is possible that they are more plentiful at the bottom of the river, however, and that these "old-time people" had some way of dredging them up.

The river is wearing the bank away where the bed crops out; consequently I had a very good opportunity of noting its position. It lies perfectly horizontal, and, for some distance up and down the river on either side of it, the caving bank is literally dotted with places where fires seem to have burned for a long time; the earth is burned hard and to redness, and ashes and coals are there. In digging out the places I found several with three stones in the center still occupying triangular positions, as if arranged for the purpose of supporting cooking utensils above the fire. These fires were generally on a level with the bottom of the shell bed.

ACCOUNT OF ABORIGINAL RUINS ON THE WILLIAMS FARM, IN HARDIN COUNTY, TENNESSEE, TWO MILES BELOW SAVANNAH, TENNESSEE.

By J. Parish Stelle.

These ruins occupy a set of ridges running toward the bottom lands of the Tennessee River, about two miles below Savannah. The fronts of the ridges terminate in steep bluffs rising fifty feet above the level of the bottom. Along the foot of the bluffs there is a series of springs, spreading and forming swampy lands, and through these lands, also at the foot of the bluffs, runs a line of earthworks, made precisely on the plan of the earthworks in the Savannah ruins, with the exception that there is but one line traceable instead of two. It seems to have been located in the swampy grounds where the springs came out, with a view to having the ditch always full of water, which must have been its condition. The redoubts are about eighty yards apart. Most of the work is traceable; the points at which it is not clearly so I have indicated on the diagram by dotted lines.

No other line of earthworks save this at the foot of the bluffs is to be seen; hence we must infer that the defenses on other sides of the town were stockades, or something of the kind. The regular line of mounds back (A, P, V, W,) would lead to the conclusion that there had been other defenses, and that these mounds were erected for the purpose of overlooking them.

All the mounds of the group were carefully opened; the markings on the diagram show the shape and position of the excavations made.

A.—This is a round-shaped mound, twenty yards across and five feet high in the center. Upon its side is a dead white oak, (*Quercus alba.*) over three feet in diameter. Went to the bottom in the center, but found nothing. Composition yellow clay without gravel, showing that the material had been taken from the surface of the ridge, as gravel occurs a short distance beneath.

B.—Ten yards across and four feet high in center. Same character as A. Cut entirely through it, but found nothing.

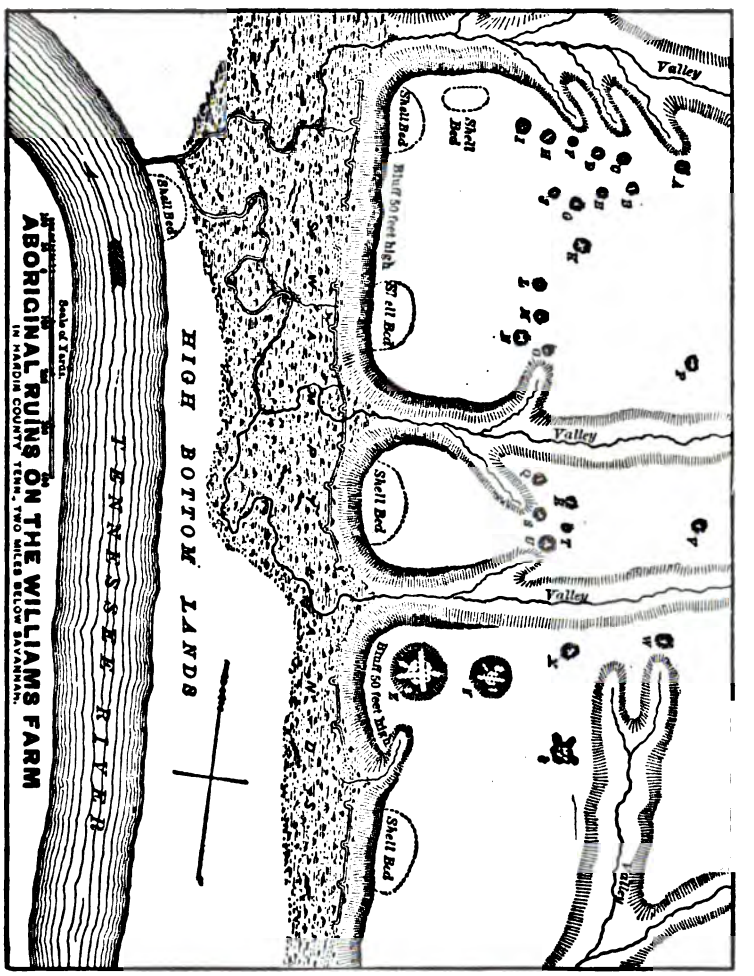
C.—Ten yards across and four feet high in center. Same character as B; opened it with same result.

D.—About same size, and precisely same character as C. Opened it, but found nothing.

E.—Ten yards across and six feet high. At eighteen inches down we came upon a human skeleton lying with its head toward the southeast. The bones were very badly decayed. There were a few shells with the bones. Nothing more was found. Upon the side of this mound there is a white oak stump over three feet in diameter.

F.—Five yards across and two feet high. Contained nothing.

G.—Fifteen yards across and four feet high. White oak tree over two feet in diameter growing upon it. At two feet down came upon a few fragments of decayed bones, so far decayed that we could make nothing of them.



H.—Twelve yards across and three feet high. On removing the surface, we found the mound to be nothing more nor less than a great shell-heap. Gave it a thorough turning, but found nothing save such things as are usually met with in these shell beds.

I.—Ten yards across and three feet high. Another mound composed partially of shells, though not entirely, as was the case with H. The shells were intermingled with yellow clay. At one foot down found a stone implement—probably a plow or hoe. You will observe that the large end of the implement is much worn, the probable result of working in the earth. There was nothing more.

J.—Ten yards wide and three feet high. Contained nothing.

K.—Twenty yards across and six feet high. Contained nothing.

L.—Ten yards across and two feet high. Contained nothing.

M.—Ten yards across and two feet high. At the bottom found a small stone implement lying alone in the yellow earth, apparently lost there when the mound was being made. There was nothing more.

N.—Twenty-five yards across and eight feet high. At two feet down came upon shells and fragments of pottery in considerable abundance. At three feet down, fragments of charcoal were to be seen, and the earth had a red appearance, indicating that it had been intensely heated. At six feet down we found an imperfect stone implement. There was nothing of further interest.

O.—Ten yards wide and three feet high. Contained nothing of interest.

P.—Twenty yards wide and five feet high. Contained nothing.

Q.—Eighteen yards wide and three feet high. A few scattering shells were found, but nothing of additional interest.

R.—Fifteen yards across and four feet high. Found one large arrow or spear-head, but nothing further.

S.—Twenty yards across and six feet high. Contained nothing.

T.—Ten yards across and two feet high. Nothing of interest.

U.—Twenty-five yards across and six feet high. A few small flint implements were found scattered here and there, as if lost at the time of building. Nothing more.

V.—Twenty yards wide and five feet high. Contained nothing.

W.—Twenty-two yards wide and six feet high. There were some traces of bones a few inches below the surface, but they were so much decayed that nothing could be made of them.

X.—Twenty-three yards wide and five feet high. Three feet down there was a deposit of black matter, looking as if some perishable substance, as a log of wood, had decayed. There was no sign of bones or anything else of interest.

Y.—Sixty yards across and seven feet high. Composed of black alluvial soil, evidently brought up the bluff from the river bottom. Examined it carefully, but found nothing.

Z.—One hundred yards across and ten feet high. Composed of black soil from the river bottom, the same as Y. Found traces of bones, evidently human, immediately on the solid earth, but the character of the soil making up the mound had caused them to decay so badly that but little could be made of them. There was nothing further of interest.

&.—Thirty yards across and twelve feet high. This mound has three arms running out from it, as shown in the diagram. They were evidently for the purpose of affording an easy ascent to the summit—the sides were, probably, too steep to be ascended with ease. Three feet down we came upon some badly decayed human bones, and with them some black substance which seems to have been matting. At seven feet

we found fragments of charcoal and red burned earth one foot thick, and four or five feet in diameter. At nine feet we found another stone implement, evidently used in working the earth. It has been broken, and on that account may possibly have been thrown away by the workmen engaged on the mound. There was nothing further worthy of note.

CHARACTER OF THE MOUNDS.

All the mounds of this group, with the exception of Y and Z, are composed of yellow clay, evidently taken from the surface of the ridges; and all, with the exception of &, are rounded on top and reasonably regular in outline. In general character, they seem to differ somewhat from the Savannah group, for none of them appear to have been places of deposit; in fact, I do not think there is a burial mound in the association. I am of the opinion that the few bones taken out are not those of the mound builders, but that they are the remains of more recent Indians, buried in the mounds by mere chance, or because their elevation above the common level gave them attractions as burial places.

The arrangement of this "Williams Farm" group has quite strongly impressed me with the belief that the mounds were made for two special purposes—one set, as A, P, V, W, and perhaps others, to stand as watch-towers, from which to overlook the defenses, and the other set, as A, C, F, O, S, U, W, X, to act as the lamp-posts of the town; that is, erected for illuminating purposes. I am led to this latter conclusion by their situation at the heads of the valleys. Fires kindled upon them even now, (and they must have been much taller originally,) would light every foot of valley making up into the town site. Add to these a few that might be selected upon the interior of the ridges, and the illumination of the entire site might be made complete. I found the same arrangement in the Savannah group. In fact, I have found it so in all the groups that I have visited.

SHELL BEDS.

There are a number of shell beds in connection with these ruins, but since they do not differ in any particular from the shell beds of the Savannah group, I have thought it best not to go into any particular exploration of them, or to trouble you with specimens.

FOSSIL WOOD.

In the same box with this I send you some specimens of fossil wood, taken from "Chalk Bluffs" on Tennessee River, in Hardin County, Tennessee. The "Bluffs" are caving banks, about three hundred feet high, washed at the base by the river.

I. The piece marked thus will explain itself. It is a sample of what I wrote you about as being part wood and part stone.

II. Fragments broken from the trunk of a tree six feet in diameter. Eight feet of what appears to be the butt end of this specimen is exposed, the remainder (no one knows how much) runs into the bluff.

III. Broken from a specimen seven feet long and four feet in diameter.

IV. Bark. Is washed out of the bluff in considerable quantities.

V. Specimens broken from the end of a log three feet in diameter, sticking squarely out of the bluff, embedded in the center of a seven-foot stratum of yellow sandstone. Bounding the stratum above and below are thick bands of iron ore.

VI. Sample of the yellow sandstone mentioned above.

VII. Sample of the deposit in which most of the fossils are found.

VIII. Specimens picked up at random about the bluffs.

TERRESTRIAL PHYSICS.

THE EARTHQUAKE IN PERU, AUGUST 13, 1868.

[*Extract from letters of John V. Campbell, superintendent of the Arica and Tacua Railroad.*]

TACUA, *November*, 1868.

The sight of Arica would fill with dismay any one who had known the place before. The destruction has been *complete*, and more need not be said, were it not that the ruins and signs of the great devastation that meet one on all sides make the aspect of the place so painful that people who once see it are afraid to look on it again. The lower part of the town is a heap of ruins, except where passages have been cleared to serve as streets, while in the upper part, beyond the reach of the tidal wave, many walls and parts of houses are still standing, but so cracked and shattered as to be quite uninhabitable, and they evidently show that, even without the aid of the sea, Arica was a mass of ruins after the heavy shock of the earthquake. Further back on the pampa, going toward Arapa, the people have built their wooden sheds in great numbers and with much regularity. It is said this will be the future site of the town.

In the part of the town that was washed by the sea the confusion of the ruins is indescribable, and the effect of the waves is bewildering. Alongside the mole is the stationary engine-boiler of the railway, also the remains of the two locomotive-tenders; up in the market-place is another tender, one of the boilers of the flour-mill, and one of the iron girders of Mr. Hegan's turn-table, all large pieces of iron weighing many tons, that have been carried by the force of the waves more than seven hundred yards. Facing Eusert's house, or rather the site where it stood, is one of the locomotives; farther on, facing Nugent's house, is another; and a few yards farther, the third, all in the sea, broken and completely worthless. The strength of the wave is, however, more apparent at San José, where the piers of the bridge have been cut off, on a level with the bed of the river, and carried in large compact blocks of masonry intact, four, five, and six hundred yards on to the highest ground behind. The tubular girders have been carried a similar distance, and many broken.

The bed of San José River has been filled up about four feet, while our embankment on each side has been washed down, and the temporary track we have built passes over the bed of the river with a culvert of only three feet. This of course the floods will carry away in winter, and how we shall ever manage to construct a permanent bridge I cannot yet

will now comprehend my long silence, as since the 30th May I have been busy at reorganization, drilling new hands, and pulling up heavy arrears of work.

As you ask me for particulars of earthquakes, I will tell you the result of my long-continued observations. Their course here is invariably from the mountain range to the sea—in this district from east by north to west by south. Walls built north and south—that is, across the course of movement—are those that suffer most. Many have fallen and all are more or less injured. Walls built east and west suffer little if at all, except occasionally when they are at the corner of the street, and then only a few of the last adobes fall.

The movements appear to have the greatest intensity or rather effect in sand. The walls of houses built on sand when they do not fall, as most frequently they do, are left in a crumbled condition, crashed and shattered in every direction. It is clear that the earthquake movement imparts a variety of movements to sand. I think, too, the force that causes the movements acts in the line of least resistance, or tries to liberate itself where it finds its work easiest.

You remember the "big cut" on the A. and T. line and the conglomerate that you so often anathematized. That conglomerate, however, resists earthquakes, and I attribute the preservation of Tacua on the 13th August, 1868, to the town being built on it. Not a stone falls in the big cut, and I have a hole in the yard of my house fifty-one feet deep, all through this formation, with an old wall two feet from its edge, that I was sure would have fallen in, but to my great surprise everything remained sound and intact. This conglomerate is, as you know, very tough and must offer immense resistance to the earthquake force.

Our rock here is all trachyte tuffa, a few stages only removed from pumice-stone, and offers little or no resistance to the earthquake shocks. Houses built on it fall easily.

The earthquake waves are low and only measure a few inches in height. The damage they cause appears to me more owing to duration than to altitude of the movement. The earthquake of the 24th ultimo lasted ninety seconds and left things standing; while a duration of five minutes would have brought them down. The effect of this last earthquake on vessels at sea you will find in the Valparaiso papers of last mail in the case of the ship Payta. The water appeared to run away from the vessel's sides, and the people in her feared being submerged. She was fifty-seven miles south of Arica, in a direct line east and west with Islaya, now, as then, in a violent state of eruption, and must have been caught in the very center of the movement.

The effects of an earthquake on a train in motion are worth mentioning. On the 13th of August, 1868, the Presidente (our very first and last engine) took up the train, (regulation load one hundred and twenty tons, cars included, but exclusive of locomotive and tender twenty-two and one-half tons,) and was going at about sixteen miles per hour when

it suddenly stopped with a smart shock. Mr. Ansdell, who was a passenger, thought something had given way on the engine, while Braithwaite, the driver, thought the stoppage was caused from behind. The train, however, would not move, so the steam was shut off and both got down to examine matters. They could hardly stand on the ground, and at once perceived the true state of the case.

Earthquakes are very frequent yet, and the people are in a state of panic, a German astronomer, Falb, having predicted our total destruction on the 30th September or 1st October; while an Englishman, Saxeby, defers the event until the 5th of October. The people are deserting Arica, and the authorities are making us bring up the custom-house to Tacua. On the railway we can barely keep our work going. In Tacua two-thirds of the population are sleeping in tents. I never before witnessed such a fright. People refuse to transact business until after the 5th of October, or when purchases are made delivery is stipulated for after that date.

Several shocks, and two very severe ones on the 20th and 24th of August, have enforced the German's predictions, and it is becoming heresy to argue against him. The Cordillera is to be the shore of the Pacific.

The anniversary of the 13th August was a great day in Arica. There were masses and religious processions to prevent a repetition of the great cataclysm, but the people were very anxious, and passed the day on the hill-tops, relieving themselves at intervals by prayer and flying visits to the taverns. All, however, passed off well.

THE ELECTRO-MAGNETIC SEISMOGRAPH.

By Prof. Palmieri, of the University of Naples.

[*Translated by B. O. Duncan, esq., United States consul, and furnished to the Smithsonian Institution by the Department of State.*]

In all the instruments invented up to the present time for registering the movement of the earth's surface, the force itself of the motion of the earth has been charged with the labor necessary for preserving the trace of the shocks; and this is the reason why slight oscillations of the soil could not be registered. In the seismograph, which I am about to describe, it is the electric current which performs the labor, and, therefore, it is possible to have a registering apparatus capable of the greatest precision even for the slightest shocks. It is also possible by means of this apparatus to perceive the register of many vibrations of the earth which would otherwise escape observation.

Suspended above a small iron cup containing mercury is a fine brass wire coiled into the form of a cork-screw, of about fourteen or fifteen turns.

The diameter of the wire is about one millimeter, and that of the spiral twenty or twenty-five millimeters. This spiral is supported at its upper extremity by a thin elastic spring, and can be elevated or lowered by means of a screw. The lower extremity of the spiral is terminated in a cone of copper, pointed with platinum, which is kept at a very minute distance from the mercury contained in an iron cup, which is placed on a column of wood or marble. The distance from the point of platinum to the mercury may be varied at pleasure, but once fixed upon it remains invariable, in spite of any changes of temperature, owing to a very simple system of compensation; the rod which sustains the spiral being of a metal which expands upward, with an increase of temperature, as much as the spiral is lengthened downward. The iron cup and the spiral are in communication with the poles of one of Daniell's galvanic batteries of two *couples*.

If the surface of the earth is agitated by a vertical shock, even scarcely perceptible, the point of platinum will touch the mercury below it, and will complete the current of the battery. Then two electro-magnets, which are in the same circuit, will attract their armatures or keepers, and the first will stop the running of a clock, which marks the days of the month, the hours, the minutes, and the half-seconds; and will thus register the exact moment of the commencement of the shock. At the very instant the clock stops it gives a signal of alarm by means of a bell. The second electro-magnet in drawing its armature sets free the pendulum of a second clock, which had been stopped out of the vertical line, and this clock in running causes a band of paper to move at the rate of three meters an hour. At the same time the armature of the second electro-magnet presses a pencil against the paper as it passes over a little pulley, and causes it to trace a series of dots on the paper, corresponding in length to the duration of the shock; the shock having ceased, the paper will continue its movement unwinding from one cylinder and winding up on another; and if another shock occurs, the pencil will register it as before by another series of dots, and thus continue; so that the intervals remaining unmarked will indicate the hours of repose, and the parts marked the duration of the oscillations.

To other spirals, formed with different numbers of coils, are suspended small magnets, under which are placed some iron filings, which adhere to the magnets when they oscillate vertically; and thus they preserve the trace of vertical shocks. One of these spirals causes a light needle to move on a graduated arc, and thus measures the extent of the oscillations.

Four glass tubes, each bent at both extremities at right angles, having thus two vertical branches, united at the middle of the base of the horizontal portion, serve to indicate the horizontal shocks; one of the two vertical branches has a diameter at least double the other, but is shorter. These four tubes are arranged in the direction of the four *cardinal points*. As they are all alike and act in the same way, it will

be sufficient to notice one of them. A certain quantity of mercury having been poured into this tube, a wire of iron or platinum is put in the branch with the greater diameter, and another platinum wire is placed at a very small distance from the surface of the mercury contained in the branch with the smaller diameter.

On the surface of the mercury contained in the branch with the smaller diameter is placed a floating piece of iron suspended by a fine silk thread, which passes over an ivory pulley, with a counter-weight so regulated that if the floating piece is raised by the mercury it remains separated from it, (at the point to which it had been raised;) and as the axis of the pulley has attached to it a long and light needle, it is evident that this needle will deviate when the floating piece rises, and that remaining fixed, it will indicate upon the arc of the graduated circle the number of degrees it has traced. If there be a horizontal shock in the direction of one of these tubes of mercury, the mercury will be agitated in the two vertical branches, but, undergoing more perceptible oscillations in the branch with the smaller diameter, it will raise the floating piece of iron, and will cause the needle to deviate in a corresponding manner. But at the same instant the mercury will touch the point of the platinum wire, and the electric current, which will thus have passage, will excite the two electro-magnets before mentioned, and will act in the same manner as already explained for vertical shocks. The deviation of the needle will indicate the direction of the shock; and if the shock is not in the exact direction of the tubes, its real direction will be indicated by two needles.

By the aid of the electric current, shocks may be registered which would otherwise escape notice on account of their extreme slightness, for the trembling of the surface has no resistance to overcome, provided that the points of platinum are placed very near the surface of the mercury. I have added some auxiliary apparatus for shocks a little more violent. For instance, I have placed at the base of the column the mercury-apparatus of Coulier or of Cacciatore. At the extremity of the metallic wire I have suspended a metal globe, which, in oscillating, moves the light horizontal tubes by which it is surrounded.

One clock is intended to make known with the precision of a half-second the beginning of the shock; but to know the hour in which the shock occurs, the other clock will suffice; for the length of the paper unrolled by the wheel, and the hours marked by the needle, will indicate sufficiently the time. This apparatus registers all the shocks that take place, indicating the duration of each and the time that elapses between them; but it cannot give the nature and intensity of each of them. By it we can know if all the shocks were vertical, and also their maximum intensity. We can likewise know if all were horizontal, and if they had the same direction, or if the direction was different. We can also know if there was one shock of one kind, and another of a different kind. This seemed to me sufficient for registering the movements (trem-

blings) of the surface, which are frequent on Vesuvius, but which are very rarely observed. The apparatus being visited at least three or four times daily, at the ordinary hours of observation, and the alarm-clock announcing the moment when the shocks occur, the instrument may always be put back into its normal condition. This is the reason why I have not thought it necessary to add other parts, which would render it more complicated.

But for violent earthquakes, which compel the leaving of the house, and which render the visiting of the apparatus dangerous, one can, by the action itself of the violent shocks, register the character, the duration, and intensity of each of them, with the aid of an auxiliary apparatus that I have long ago prepared in my mind, but which I have not yet had executed. My principal object was to discover the slight movements of the surface which hitherto escaped us entirely. The seismograph above described has not only given me the surest indications of approaching eruptions of Vesuvius, but it indicates also the violent earthquakes which occur in Italy and the entire basin of the Mediterranean, even the eruptions of Etna and of Santorin.

In localities exposed to violent earthquakes this apparatus should be placed on a solid foundation of masonry, constructed immediately on the surface, and protected by a covering of wood capable of resisting the shocks.

ON THE DISTRIBUTION OF FOREST-TREES IN MONTANA, IDAHO, AND WASHINGTON.

By W. W. Johnson.

In accordance with the promise made, I submit the following views of the distribution of forest-trees over that portion of the Northwest comprising the Territories of Montana, Idaho, and Washington, or more particularly the region extending from the forty-fifth to the fiftieth parallel of north latitude and from the one hundred and tenth meridian to the Pacific Ocean. This part of our continent is traversed by three systems of mountains, the Rocky, Bitter Root, and Cascade Ranges. The mountain system of the two first named occupy a space of about two hundred miles in width, or from about the one hundred and twelfth to the one hundred and seventeenth meridian, while the latter lies in the vicinity of the one hundred and twentieth meridian, and their general direction is north and south; these are approximate locations, and are stated as limits of description. The traveler through the Rocky and Bitter Root Mountains would be unable to tell where he left the one or entered the other. The valleys of the main water-courses are broad and timberless, while the banks of every stream are fringed with a belt of cottonwood, with willows, alders, and a small birch undergrowth. While the mountain spurs and ridges which form the boundaries of these

valleys, and in which these streams take their rise, are timbered more or less heavily with the several varieties of firs and pines, the loftier ranges, say from six thousand to eight thousand feet in altitude, are clothed with a thick growth of tall black pines, which are from three to ten inches in diameter, of from thirty to fifty feet in height, while the lower ranges and spurs have firs and pines from saplings up to six and nine feet in diameter, the tallest trees being probably from one hundred to two hundred feet in height. Geological formation has something to do with the growth and variety of timber, the granitic soils being apparently preferred by the pines, while the firs are the most abundant on the limestones and old red sandstones. Upon nearing the limits of vegetation upon the many peaks whose summits are seldom destitute of snow, the stunted pine appears to be the only tree which struggles there to maintain its foothold.

West of the Bitter Root River, which washes the eastern base of the formidable range of mountains called in one locality the Bitter Root and in another the Cœur d'Alene Mountains, the character of the country changes. The streams which meander in sinuous courses through the cañons, gorges, defiles, and ravines of this region, which has a width of from seventy to one hundred and forty miles, are confined to narrow beds between mountain spurs, and the entire face of the country is covered with a forest which has forbidden, until lately, even the hardy and adventurous miner from exploring its fastnesses, and determining the heads and courses of its draining streams. After leaving the western base of this mountain-bed we enter the great plain of the Columbia, where no trees are seen, except along the water-courses, as on the eastern side of the mountains, over a vast plain which presents to the eye the appearance of a rolling ocean tossed by contending billows. Crossing this plain, up nearly to the summits of the Cascade Mountains, a distance of about one hundred and fifty miles, we again enter into the timber, which stretches thence in an almost unbroken forest to the Pacific, where the trees of pines and firs assume gigantic proportions, and have given to Washington Territory the reputation of affording the best spar and ship timber in the United States, if not in the world. To the north, when you enter into the region of the Upper Columbia and its tributaries, which rise in the damp lake country of the British possessions, as far as my experience goes, the fiftieth parallel, the country yields as fine a growth of timber as in the mountain regions to the south of it, similar in character, but wider in its extent. This country is devoid of any extensive prairies, and is but sparsely inhabited, and has been imperfectly explored.

Having thus given the outlines of the distribution of the trees over the tract set forth, I would suggest the theory which presents itself to my observation, as accounting for the treeless valleys, prairies, and plains which form so large a part of our great West. When I first entered that country, nearly eleven years ago, I was much struck by the absence of

rains in summer on these plains. Showers would come up as they do in the eastern part of the United States, but seemed to be drawn and swept along the sides of the mountains, where they expended their moisture, giving only to us in the prairies the comfort of their shadows. I noticed this in a residence of some five years in the Walla-Walla Valley, on the southern boundary of the great plain of the Columbia, as well as in the many valleys of Montana. Living, as I have for several summers, under canvas, and my business calling my attention to the clouds and the trees, my experience there corroborates my observation in Walla-Walla, as showing that the showers of summer are of much more frequent occurrence along the mountain-sides, and are always of longer duration among the timbered peaks and foot-hills than in the lower and treeless portions of the country. The trees grow always along the streams, where there is a constant supply of water, although the soil may not differ in any material respect from that in the immediate vicinity, which, being dry and unnourished by rains, afford no nutriment to the seeds of the cottonwood, the pine, or the fir. Not only the absence of rains in summer, but the absence of snows in winter, are a preventive to the growth of forests. Thus, we see these valleys are seldom visited by snows of any depth, from twelve to twenty-four inches being the limits of deposit in ordinary winters, and frequently the fall over their surfaces does not reach a depth of over five or six inches, while in the elevated lands of the mountains in the timber, snows of from three to seven feet are of almost universal occurrence every winter, and in the northern latitudes referred to, while the altitude is not so great, still the snow deposit is as great and as widely diffused.

As another evidence of moisture being a controlling element in the growth of trees, wherever a spring starts out of a mountain-side, otherwise treeless, a clump of timber marks the spot, and is an almost sure sign of its presence; and wherever a tree is planted and supplied with its requisite amount of water, the growth is as thrifty, as healthy, and as enduring as in its native forest.

INFLUENCE OF THE AURORA ON THE TELEGRAPH.

By W. D. Sargent.

Harrisburg, Pennsylvania, *September* 27, 1870.

I take the liberty of laying before you some crude observations of mine on the effect of the aurora on telegraph lines on the nights of the 24th and 25th instant.

Saturday, September 24th, the wires were very much interrupted all the evening, and we supposed a storm was gathering in the west, but the appearance of the aurora between 8 and 9 p. m. discovered the real cause of the trouble. The light and flashes increased in brilliancy and

color up to about 11 o'clock, when the whole northwestern part of the heavens was a brilliant red, reaching to the zenith, the color fading gradually to the north to a strong white light, and then rising again in the northeast, but not so brilliantly as in the northwest. At this time (11 p. m.) I came to the office and had one of our lines disconnected from the batteries and the ends grounded at Harrisburg and Philadelphia. This arrangement gave a current a trifle stronger than the regular batteries and in the same direction, galvanometer deflecting to the right. At 11.45, after one or two breaks, the current changed, the galvanometer needle deflecting to the left; at 11.55 back to the right; at 12.10 to the left, where it remained until 1 o'clock, when I went home.

After the galvanometer needle deflected to the left, at 11.45, the current became very unsteady and weak; was only sufficiently strong to move the relay for a few minutes at a time. The galvanometer showed a current of varying strength all the time.

Sunday, September 25th, the aurora again appeared about 8.30 p. m., but not near so brilliant as on the former evening.

I had a wire connected as before, viz, to the ground at Harrisburg and Philadelphia. This produced no effect whatever on the relay. The galvanometer at 8.40 deflected to the left; 8.45, right; 9, left; 9.20, right; 9.21, left; here the current was very changeable, the needle fluttering from side to side; at 9.22 again to the right, where it remained until 10 p. m., when I went home.

The galvanometer I have is Dr. Werner Siemen's universal galvanometer.

[The change in direction of the current may possibly have been due to the greater action of a beam of the aurora on the easterly part of the wire between Harrisburg and Philadelphia, and afterward of another beam on the westerly part of the wire. It is therefore important to note whether a change of a similar kind takes place in a wire extending north and south.—J. H.]

METEOROLOGY.

NEW CLASSIFICATION OF CLOUDS.

By Professor Andre Poëy,
Late director of the observatory at Havana.

HISTORICAL SKETCH.

The meteorologists of antiquity felt the need of distinguishing the different appearances of clouds, but were, at the onset, completely bewildered by the great variety of form which they assumed, apparently without order. Aristotle* first studied the phenomena of clouds in relation to their optical properties—their power of reflecting and refracting light, and the production of rainbows, halos, and coronas. Theophrastus,† his disciple, afterward vaguely observed the forms of clouds relative to the predictions of change of weather. He remarked, for example, that the appearance of straight horizontal layers of clouds on the summits of mountains is an indication of wind and rain; but these attempts evidently must have failed, because the natural classification of objects in the time of Theophrastus was unknown. It was not until 1801 that the great naturalist Lamarck,‡ and in the year after the celebrated English meteorologist Luke Howard,§ perceived the possibility of referring the clouds to some fundamental types, following the example of the natural classification for living beings adopted by Linneus. Lamarck, who pointed out the importance of the study of the forms of clouds, determined six principal types, which he denominated clouds *en balayures*,

* Aristotle.

† Theophrastus.—Liber de ventis, et opuscula de signis pluviarum et tempestatis, auct. Theophrasto, in lat. vèrs. et illustr. apud Franciscum de Franciscis Bonaventura, Venetiis, 1594, 4 parts, 1 vol., 4to; Eresii Theophrasti qua supersunt opera et excerpta Librorum quatuor tomis comprehensa Jo. Gottlob Schneideri, Lipsiæ, 1818–'21, 5 vol., 8vo, vol. ii, pp. 466–476, 599–605; vol. iv, pp. 719–756; vol. v, pp. 163–173.

‡ Lamarck.—Annuaire meteorologique, Paris, an x, No. 3, p. 149; an xi, No. 4, pp. 126–128; an xii, No. 5, p. 159.

§ Howard.—Tilloch's Philosophical Magazine, 1803, vol. xvi, pp. 97–107, 344–357; vol. xvii, pp. 5–11, pl. vi, vii, viii, with some changes not affecting the nomenclature in Ree's Cyclopædia, 1819, vol. viii, art. *cloud;* in Nicholson's Philosophical Journal, 1812, vol. xxx, pp. 35–62, without plates; in supplement to the Encyclopædia Britannica, 1824, vol. iii, pp. 202–205, art. *cloud*, with plates, and the addition of a set of new terms for the modifications, intended for the use of English readers; The Climate of London, London, 1833, vol. i, pp. xxxix–lxxii; On the Modifications of Clouds, and on the Principles of their Production, Suspension, and Destruction, being the substance of an essay read before the Askesian Society in the session from 1802 to 1803, issued separately, in 1832, London, 8vo., without plates; id., London, 1864, in 4to, with lithographs.

(sweeping;) *en barre*, (bars;) *pommelés*, (curdled;) *groupés*, (grouped;) *en voile*, (veil;) and *attroupés*, (piled.) The year following, 1802, Luke Howard proposed a classification of clouds still more elaborate than that of Lamarck. It is a remarkable fact that these two savants, who labored independently of each other on clouds observed in two different countries, should have arrived at almost the same fundamental types, and especially at the determination of the same clouds, though designated by different denominations. Thus, in the seven types which Howard has established, we find the first five types of Lamarck, according to the following table:

Types of Lamarck.	Types of Howard.
En balayures, (sweepings)	Cirrus.
En barre, (bar)	Cirro-stratus.
Pommelés, (curdled)	Cirro-cumulus.
Groupés, (grouped)	Cumulo-stratus.
En voile, (veil)	Nimbus.

As to the two other clouds of Howard, the *stratus* being but a mist, and the *cumulus* corresponding entirely to his own *cumulo-stratus*, since he made double use of these identical forms, we see how the five true types of Howard are fundamentally the same as those of Lamarck. If we consider that my new type of *fracto-cumulus* is found in the classification of Lamarck under the name *nuage attroupé*, (piled cloud,) adding besides my two other types of *pallio-cirrus* and of *pallio-cumulus*, the last being a modification of Howard's *nimbus*, we have the classification of clouds established by me in 1863, which I shall describe in the following exposition. The types which served as the base of Howard's nomenclature were very happily chosen, since, as Kämtz well observed, they are connected with anterior atmospheric changes, and consequently furnish us with indications of approaching change of weather. Howard in his classification, which is almost entirely based upon the form of the clouds, distinguishes three simple modifications: The *cirrus:* parallel flexions, or diverging fibers, extensible by increase in any or in all directions; the *cumulus:* convex or conical heaps increasing upward from a horizontal base; the *stratus:* a widely extended, continuous, horizontal sheet, increasing from below upward, from which the two following intermediate modifications are derived: The *cirro-cumulus:* small, well-defined, roundish masses in close horizontal arrangement or contact; the *cirro-stratus:* horizontal, or slightly inclined masses attenuated toward a part or the whole of their circumference, bent downward or undulated, separate or in groups consisting of small clouds having these characters; and, finally, the two following compound modifications: The *cumulo-stratus:* the *cirro-stratus* blended with the *cumulus*, and either appearing intertwined with the heaps of the latter, or *superadding a wide-spread structure to its base;* the *cumulo-cirro-stratus vel nimbus:* "The rain-cloud, a cloud or system of clouds from which rain is falling. It is a horizontal sheet, above which the *cirrus* spreads, while the *cumulus* enters it laterally and from beneath." I shall point

out below the faulty interpretation which has been given by all the writers to the description of Howard's two types of clouds, the *stratus* and *nimbus*, then the defects of this nomenclature, which I reject, and the new classification which I substitute, although since the time of Howard no other classification having been hitherto proposed, the following are some partial attempts which have been made on the subject.

In 1815 Thomas J. M. Forster* reproduced, with some remarks, Howard's description of clouds, adding an English nomenclature of common names. In 1817 A. Müller† proposed the removal of some obscurities in Howard's descriptions, founded upon observations which he had carried on for twenty years at Vienna, in the north of Germany, upon the northern and southern slopes of the Alps, on the banks of the Rhine, and in France. In 1832 the celebrated meteorologist Kämtz‡ determined a new form of clouds under the name of *strato-cumulus*, or night-clouds; that is to say, the reverse of Howard's *cumulo-stratus*. But before his death, M. Kämtz himself acknowledged to me that he no longer attached any importance to his *strato-cumulus*, and that I could erase it from the nomenclature of couds. In 1857–'58 W. S. Jesons§ published two notes upon the form of *cirrus* and other clouds. He endeavored to account for their formation by laboratory experiments, which he had made with vapor of water. In 1863 the lamented Admiral Fitz Roy,‖ having in charge the meteorological department of the Board of Trade, (London,) proposed the adoption of an augmentative termination in *onus*, and a diminutive in *itus*, to the nomenclature of Howard, in the following manner: From *cirrus* he forms *cirronus* and *cirritus;* from *cirro-stratus*, *cirrono-stratus* and *cirrito-stratus*, and so on. Not only does this modification refer to the less or greater quantity of clouds without changing the primitive form, but it is subject to great error in practice without being warranted in this by either the observation or the plates of Fitz Roy. Finally, in 1863, I proposed to the Academy of Sciences of Paris the determination of the new types, which I have named *pallium* (*pallio-cirrus* and *pallio-cumulus*) and *fracto-cumulus*, the description of which will be found farther on.¶ When one considers the imperfection of Howard's old classification, the difficulties of distinguishing each stratum of clouds,

* Forster.—Untersuchungen über die Wolken und andere Erscheinungen in der Atmosphäre, Aus. d. Franz, 2. Auflage, Leipzig, 1819; Researches about Atmospheric Phænomena, London. 1815, 2d edition, pp. 1–113; id., London, 1823, 3d edition, pp. 1–113.

† Müller.—Gilbert's Annalen der Physik, 1817, vol. lv, p. 102; Bibliothèque universelle de Génève, 1817, vol. v, pp. 6–12.

‡ Kämtz.—Lehrbuch der Meteorologie, Leipzig, 1831, vol. i, p. 377; Vorlesungen über Meteorologie, Halle, 1840; id., translated by Ch. Martins, Paris, 1843, p. 115, pl. iii.

§ Jesons.—Philosophical Magazine, 1857, vol. xiv, pp. 22–35; 1858, vol. xv, pp. 241–255.

‖ Fitz-Roy.—The Weather Book, London, 1863, p. 391, pl. ix, x.

¶ Poëy.—Sur deux nouveaux types de nuages observés à la Havane, denommés *pallium* (pallio-cirrus et pallio-cumulus) et fracto-cumulus—Comptes-rendus de l'Académie des Sciences de Paris, 1863, vol. lvi., p. 361; Annuaire de la Société Météorologique de France, 1863, vol. xi, p. 53.

with their corresponding elements, and especially the considerable length of time that an observatory must spend in making a good observation, according to our present faulty method, we are less surprised at the little progress that a study so interesting has hitherto made. I must add an important fact, which has passed completely unnoticed: that the classification of Howard also is faulty in the definition of *stratus* and *nimbus*. Kämtz's treatise on meteorology gives the following definition of *stratus*, which has been since blindly adopted by all meteorologists: "It is a horizontal *band*, formed at sunset and disappearing at sunrise." On the contrary, Howard's definition has always been that the *stratus* "is the lowest of clouds, since its inferior surface commonly rests on the earth or water; this is properly the cloud of the night, the time of its first appearance being about sunset. It comprehends all those creeping *mists* which, in calm evenings, ascend in spreading sheets (like an inundation) from the bottom of valleys and the surface of lakes, rivers, and other pieces of water to cover the surrounding country." In continuation, Kämtz, describing the *cirrono-stratus*, remarks that "these clouds form horizontal strata, which, at the zenith, seem composed of a great number of thin clouds, while at the horizon, where we perceive the vertical projection, we see a long and very narrow band." Thus for the *stratus* we have a horizontal band, and for the *cirro-stratus* at the horizon another band, *long and very narrow*. According to this savant, between these two bands there is no distinctive mark save the hour at which they appear. But as the bands *cirro-stratus* are frequent exactly at the rising or setting of the sun, it is very difficult to distinguish these two orders of clouds. It must be added that the *cirrus* and the *cirro-cumulus* show a tendency to dispose themselves in bands parallel with each other, which at the horizon may be equally confounded with those of *stratus* and *cirro-stratus*. As to the origin of the *stratus* can we, without confusion, give the name of cloud to a phenomenon already designated as *mist?* The sole connection which exists between a cloud and a mist is in the first precipitation of vapor of water in the atmosphere, and its greater or less condensation. It is when the mist is elevated to the region of inferior clouds that it is condensed under the form of a *cumulus*, and the visible vapor of water takes its first forms. Hitherto the mist was but a shapeless mass of vapor molded, so to speak, by the accidents of the earth and sheets of water, and following the permanent or transient outlines of these surfaces. It seems that Howard's first error was calling a mist a cloud, and the grave responsibility rests upon his successors of giving the mist of this writer as a true cloud under the form of a *horizontal band*. This error has been extended to the different plates published in 1815 by Forster, in which, nevertheless, the *stratus* is not given as a band, but rather as a mist raised at the horizon. But this representation is equally faulty, as it gives no idea of a mist covering the surface of the earth. As early as 1820, in Brande's* work, the *stratus* appeared as forming a *horizontal*

* BRANDES.—Untersuchungen zur Witterungskunde, Leipzig, 1820, p. 385.

band, which was reproduced by Kämtz in 1840, and by Schübler* in his four splendid engraved plates in 1849. In fine, the plates which were published by the Smithsonian Institution† at Washington, and in 1859 by the chart department of the French minister of marine,‡ to serve as instructions for seamen and observers, were reproductions of those of Kämtz. The French edition alone contained two plates, of which the first embraced the simple forms of clouds, *cirrus*, *stratus*, *cumulus*, and *nimbus*, and the second the compound forms, *cirro-cumulus*, *cirro-stratus*, and *cumulo-stratus*, with four variable *cirri*. Howard's Plate VI, on the contrary, published in 1803 for the first time, in Tilloch's Philosophical Magazine, represents the *stratus* as a *mist* spreading above a lake surrounded by hills. Thus far in relation to the erroneous interpretation given to Howard's *stratus*. We now proceed to note another error hitherto propagated, relative to the *nimbus*. In the first place, Kämtz's definition, which all the late meteorologists have adopted, is as follows: When the *cumulus* is piled up and becomes more dense it passes to the state *cumulo-stratus*, which often takes at the horizon a black or bluish tint and passes to the state of *nimbus*, or rain-cloud. This is distinguished by its uniform gray tint and its broken edges, the clouds which compose it being so much confounded that it is impossible to distinguish them. Thus the single primordial and distinctive character which results from this definition is that of a rain-cloud, and therefore we shall call every rain-cloud *nimbus*, as has been done to the present time. Its secondary characteristics are: 1st, a tint of uniform gray; 2d, its edges broken; 3d, confusion of all the clouds of which it is composed. All this gives no idea of the most essential element, namely, the *real form* of the rain-cloud. Though the definition of Kämtz, and other writers, is not that of Howard, this observer has not given one more intelligible and exact. We see that he unconsciously felt the formation of rain-cloud, but was not very settled in his description. I am speaking of the *double superposed stratum*, the inferior formed of *cumulus*, which it designates, and the second superior stratum of *cirrus*, whose existence was vaguely felt by Howard. The remainder of his definition is *cumulus cirro-stratus vel nimbus def. nubes vel nubium congerieo (superné cirrata) pluvian effundens.* A cloud or system of clouds from which rain is falling is called a rain-cloud. It is a horizontal sheet, above which the *cirrus* spreads, while the *cumulus* enters in laterally and from beneath. In other isolated passages of his long description of the nimbus, the idea of this double stratum appears yet more plainly. "Clouds, in any one of the preceding modifications, may increase so as completely to obscure the sky. Before this effect takes place there exists, *at a greater altitude*, a thin, light veil, or at least a hazy turbidness.

* SCHÜBLER.—Grundsätze der Meteorologie, Leipzig, 1849.

† SMITHSONIAN INSTITUTION, Washington, D. C.

‡ VANEECHOUT.—French translation of the "Explanations and Sailing Directions of Lieutenant Maury," Paris, 1859, 4to.

When this has considerably increased we see the lower clouds spread themselves till they unite in all points and form one *uniform sheet.* It will rain during this state of the *two strata* of clouds, one passing beneath the other and each continually tending to horizontal, uniform diffusion, (the *superior stratum* is often seen in this case to partake of *cirrus*,) although they should be separated by an interval of many hundred feet in elevation. The intermediate space on these occasions is not supposed to be at any time free from a conducting medium of different watery particles, enabling the opposite electricities to neutralize each other." Hence we see that this description of Howard's *nimbus* has no connection with that given by Kämtz and the late writers, of a cloud intermediate in form, which, according to the latter, is supposed to have the property of producing rain. It is not the property of any cloud to produce rain, but it is produced by the reunion by the electric action and reaction upon the aqueous vapor of two superposed strata of clouds, the superior being *cirrus* and the inferior *cumulus.* It is this latter circumstance that Howard has neglected to properly establish. All the plates which have been published, not excepting that of Howard, give no idea of this double stratum which constitutes the rain-cloud, that is, the *nimbus* of Howard, or properly my *pallium*, (*pallio-cirrus* and *pallio-cumulus.*) I now proceed to point out the error equally inherent in the three orders of clouds denominated *cumulus*, *cumulo-stratus*, and *strato-cumulus*, and to show that they can all be reduced to the second type of *cumulus.* I remark, in the first place, a great confusion, or it may be a great similitude, between the *cumulus* and the *cumulo-stratus;* afterward I observe in the sky other cumuli, whose characters partake of more than these two types; for example, M. Kämtz's definitions, which are generally accepted. M. Kämtz says: "The cumulus is often seen in the form of a hemisphere, *reposing upon a horizontal base.* Sometimes these hemispheres are piled one upon the other, forming those great clouds accumulated at the horizon, which resemble at a distance mountains of snow."

Now for the *cumulo-stratus:* "When the *cumulus* is piled up and becomes more dense, it passes to the state of *cumulo-stratus*, which often takes at the horizon a black or bluish tint and passes to the state of *nimbus* or rain-cloud." Thus, it is sufficient that the *cumulus* be piled up and become *more dense* in order to be changed into *cumulo-stratus*, strikingly implying great development in the horizontal base, which is not mentioned, though it is one of the most essential characters of this type of clouds. While, on the other hand, this horizontal base is expressly pointed out in Kämtz's definition of *cumulus.* In a word, these fundamental points are found equally in the formation of *cumulus* and *cumulo-stratus:* 1st, a horizontal base; 2d, a superior hemispherical dome; 3d, a formation by increase from below upward. The points of difference as to the *cumulo-stratus* rest upon the irregularity of the base of the convex summits, and the aggregation from below upward,

upon the greater density, dark coloring, and semblance of their isolated masses to a mountain chain. These differences are so accidental and insignificant that Howard and Forster could not distinguish them in their definitions, and they are forced to aver that these characters were found here and there at such points that they were easily confounded. We see there is no reason to maintain a radical separation and a double denomination for two forms of clouds which are of the same kind and whose slight modifications are not even continued. It is therefore more exact to preserve the single denomination of *cumulus* for this second type, which embraces at once the two characteristic forms of cloud—on the one side the accumulation of hemispheres, and on the other the horizontal base, which are always inseparable.

Let us now pass to Kämtz's description of *strato-cumulus:* "It is composed of dense cloudy masses, round or extended, badly defined at the edges, which appear in the afternoon, increasing toward evening, until during the night the whole sky is completely covered, disappearing the next morning some hours before sunrise and finally replaced by the true *cumulus.* These *strato-cumuli* are composed of very dense versicular vapor, like the *cumuli* and *cumulo-strati.* They differ by their dependence on different hours of the day; they have also some analogy with the *strati* by reason of their extension, but are distinguished by greater altitude; yet they approach the cumuli. In winter the *strato-cumulus* often covers the sky during entire weeks; but as the sun approaches the zenith, his rays dissolve these clouds, the vapors rise, and the *cumuli* are formed." We find again in Kämtz's definition of *strato-cumulus* the same confusion as in Howard's description of *cumulo-stratus,* which I pointed out above. The terms "cloudy masses *rounded,* extended, or yet badly defined at the edges," embrace three expressions which are mutually exclusive, so that it is impossible to know the true form of the cloud, for if the cloudy masses are *rounded* they are not extended in Kämtz's sense, and still less are their *edges badly defined.* As to the physical constitution of the *strato-cumulus,* it is the same, according to Kämtz, as that of *cumulus* and *cumulo-stratus,* that is to say, composed of very dense versicular vapor.

In fine, "the *strato-cumulus* approaches the *stratus* by its exterior, but is separated from it by greater altitude." I have already said that we can compare the *stratus-mist* with no other form of cloud. Hence nothing remains but the hour of the appearance and disappearance of the *strato-cumulus,* (which seems to be the fundamental distinction Kämtz wished to establish,) to separate them from the *cumulus* and *cumulo-stratus,* added to their continuance in winter for whole weeks at a time. In a word, the *strato-cumuli,* with Kämtz, are the clouds of the night and of winter, predominating during the absence of the solar rays, and dissolved on the appearance of the sun. On this latter circumstance, we remark that the distinction of clouds of the night made by Kämtz and Howard appears to have no foundation; I have never been able

to perceive them. So true is this, that these two savants are nowise agreed upon this point, which has given rise to the new variety of Kämtz. With Kämtz, the cloud of night is the *strato-cumulus*, while with Howard it is the *stratus*. On the other hand, since the *stratus* is not a true cloud according to Howard himself, but simply a mist or hoar-frost, the distinction between the cloud of night and the cloud of day must become wholly superfluous. I will close this proof of the non-existence of *strato-cumulus* by reminding the reader that Kämtz himself told me before his death, without discussion, that he no longer attached any importance to his cloud of night, and authorized me to erase it from the nomenclature of Howard. In the exposition of my new classification of clouds, published in 1855, in the *Annual of the Meteorological Society of France*, while pointing out the identity of the *cumulus* and *cumulo-stratus*, I retained both these determinations, because the term *cumulus* did not designate its peculiar cloud-type as well as *cumulo-stratus*. But, as *cumulo-stratus* is derived from two species of clouds, it is preferable to keep the generic name of *cumulus* for the two identical clouds described by Howard, attributing to them the character given above.

DEFINITION OF CLOUDS.

Every country, according to its geographical position, topography, &c., has its own type of clouds. Here the *cirrus* predominates; there the *cumulus*. All these different appearances of clouds are everywhere intimately connected with some particular condition of climate, which powerfully influences health, agriculture, navigation, and a thousand other objects of importance to humanity. They show us at every instant the direction, the velocity, and the altitude of the superior currents which afterward determine the winds at the surface of the earth. We may regard the clouds as a weathercock in the sky, constantly indicating changes so long as a single one, however small, exists, and therefore a profound study of them, in their diverse, scientific, and social applications, becomes of high importance. For this we should consider their nature, form, quantity, direction, velocity, and azimuthal rotation.

Despite the scientific interest and the practical value which is attached to this subject, the study of clouds is unhappily in its infancy. It is rarely we find clouds included in the meteorological registers, and when they are so the characteristics above mentioned are omitted. Some observers simply write "clouds;" others denote the form, or, it may be, the quantity, the direction, or perhaps all these three elements, but neglect the velocity, and especially the azimuthal rotation to which I was the first to call attention and which is not yet understood.

We now proceed to present the basis of a new classification more in harmony with the actual facts of the science, and which is the fruit of twenty years' assiduous study of clouds in the Antilles, Mexico, the United States, and Europe. From the beginning of my meteorological investigations in the tropics, where the entire phenomena of the atmo-

sphere assume a character of simplicity unknown in higher latitudes, I have more and more felt the necessity of a reform of Howard's nomenclature. I was unable to understand his *stratus*, *nimbus*, *cumulo-stratus*, and *strato-cumulus*. It was not until I had an opportunity to consult Howard's original work that I perceived the errors into which Kämtz and other meteorologists had fallen. I had then to introduce into Howard's classification the modifications which the continued progress of meteorology requires, in order that the nomenclature may be more in harmony with our advances in this line. I acknowledge with pleasure that Howard's classification, which has existed without a rival for more than half a century, was originally based upon profound study, directed by great acuteness of observation; unhappily, however, it is too plainly stamped by the locality where his studies were prosecuted. I refer to the gray and cloudy sky of Great Britain, whence result his *strato-mist*, his imperfect distinction of the two great strata *cirrus* and *cumulus*, or his *nimbus*, (the rain-cloud,) the difference which he has established between *cumulus* and *cumulo-stratus*, besides many other faulty details of description in relation to *cirrus*, *cirro-stratus*, and *cirro-cumulus*.

I shall now proceed to give the derivation of my three new clouds. When certain clouds spread out uniformly over the whole face of the heavens and assume a gray or ash color, under which state rain may occur for hours or whole days, what name do we give them? They are not Howard's *nimbus*, as we conceive them, and as they are generally described; they are neither stormy nor electrical; they yield only a fine and continuous rain. Under this stratum we see constantly other clouds of more or less extent, but always isolated, becoming lost in it and increasing its thickness. But just before this stratum begins to break up, and during this operation, we see these same formless fragments detach themselves and fly to other regions. This inferior stratum is not alone; for when its disruption is completed we see through it another stratum of clouds, whiter and less dense, which breaks up in its turn, and ends by disappearing in an opposite direction to that of the inferior stratum. Have we a name for this variety of cloud so common in time of rain from the inter-tropical regions to high latitudes, especially in winter during the fall of snow? Does Howard's term *nimbus* and his description of it answer for its designation? Certainly not. We apply the name *nimbus* to the single storm-cloud, as well as to this inferior stratum, or to the united strata, and this without electrical manifestations. To this cloud I give the name *pallium*. When the superior stratum is formed of *cirrus* it constitutes the *pallio-cirrus*, and when the inferior stratum is formed of *cumulus* it constitutes the *pallio-cumulus*. The fragments of clouds, which differ entirely from the *cumulus* or *cumulo-stratus*, are the *fracto-cumulus*.

From what has been said, the necessity of distinguishing these two strata by different names is evident; but this necessity results, more-

over, from the fact that the stratum of *cirrus* is formed many hours, and even days, before that of *cumulus*, especially in the equatorial regions, and disappears after it. Without this distinction, we are obliged to call the first stratum of the *pallium cirrus*, and the second *cumulus;* but as, under this state of strata, the form and physical properties of *cirrus* and *cumulus* change completely, confusion and errors continually result.

Regarding Howard's classification as a whole, while retaining the two types of *cirrus* and *cumulus*, together with his two derivative clouds, *cirro-stratus* and *cirro-cumulus*, I reject entirely his *stratus*, *nimbus*, and *cumulo-stratus*, as well as the *strato-cumulus* of Kämtz, for the following reasons: The *stratus*,* because it is not (according to Howard) a cloud properly so called, but a *mist*, or *hoar-frost*, or the effect of optical illusion, a *cirrus*, *cirro-stratus*, or *cirro-cumulus*, seen in perspective near the horizon; the *nimbus*, for the reason that the name is an inexact denomination applied to an idea as vague as it is incorrect from the moment that *cumulus* is not truly rainy, as far as it is found displayed, forming a stratum as dense in appearance and below a second superior stratum of *cirrus*, equally rainy; the *cumulo-stratus*, because it differs in nothing from *cumulus*, according to Howard's own definition, these two forms possessing in common the three fundamental characteristics of his cloud-types and their derivatives, namely, horizontal bases, superior hemispherical basins, and the ascending aggregation of their aqueous particles; and, lastly, *strato-cumulus*, (Kämtz's cloud of night,) because this modification answers no better to *clouds of night* than Howard's *stratus*, and because its other characteristics correspond to *cumulo-stratus*.

On the other hand, as I have said before, I substitute for *nimbus* the *pallium*, which I subdivide into *pallio-cirrus* and *pallio-cumulus*, according as its stratum is composed of *cirrus* or *cumulus*. This term has the triple advantage of embracing the character, the form, and the effect, as the *cirrus* or *cumulus* forms the rainy stratum. I introduce, in fine, the definition of a second intermediate form, which can be rigorously distinguished from the preceding by the double relation of cause and effect. This is the *fracto-cumulus*, fragments of cloud floating about without determined form. Before their transformation into *cumulus*, they are precipitated or detached from the inferior surface of *pallio-cumulus*, and are spread out in horizontal bands at the top of the *cumulus* on the approach of gusts of wind. These *fracto-cumuli* differ from the *cumulus* in that they have neither the horizontal base nor the superior hemispherical form, while they are not much extended; but when they are a little more increased we see at once forming at the center of the fragment a space more dense and blackish than the rest, which gradually settles until it constitutes the horizontal base of the *cumulus*, (*vel cu-*

* In Howard's Plate VI, published in Tilloch's Philosophical Magazine, in 1803, he represents this cloud as a mist spreading above a lake surrounded by hills. All succeeding meteorologists have misunderstood this plate, and given the *stratus* as a band spread out at the horizon.

mulo-stratus,) the upper part becoming rounded by degrees. Thus the *fracto-cumulus* is the infancy of the *cumulus*, otherwise called *cumulo-stratus*, the terms being synonymous.

This new classification is wholly based upon the *nature*, the *form*, the *quantity*, the *direction*, the *velocity*, and azimuthal rotation of the clouds of each stratum, fully characterized by the origin, intimate constitution, and meteoric products of the vesicular vapors and congealed particles which constitute them; for, in the intimate nature of clouds, there is one fundamental condition to be established, depending upon the physical force which first acts upon their constitution: it is the element of *heat*. Clouds are therefore distinguished into *snow-clouds* and *ice-clouds*, of which the constituent particles are more or less congealed; then into clouds of aqueous vapor, of which the vesicles, empty or full, float in a medium above the freezing-point.

Under this fundamental aspect, there are but two types of clouds, properly so called, the *cirrus* and the *cumulus*. To the *cirrus* are attached three transitional forms, the *cirro-stratus*, *cirro-cumulus*, and *pallio-cirrus*; and to the *cumulus*, two other transitional forms, the *pallio-cumulus* and the *fracto-cumulus*.

The following is a table of my new classification of clouds compared with that of Howard:

NOMENCLATURE OF HOWARD.

First type..... *Cirrus*.
Derivatives .. .. { Cirro-stratus. / Cirro-cumulus.
Second type..... *Cumulus*.
Derivatives ..... Cumulo-stratus.
Third type ..... *Stratus*.
Derived from the three types..Nimbus.

NEW NOMENCLATURE OF POËY.

First type..... *Cirrus*.....		
Derivatives	Cirro-stratus	Ice clouds; snow clouds.
	Cirro-cumulus	
	Pallio-cirrus	
Second type..... *Cumulus*.....		
Derivatives.....	Pallio-cumulus	Clouds of aqueous vapor.
	Fracto-cumulus....	

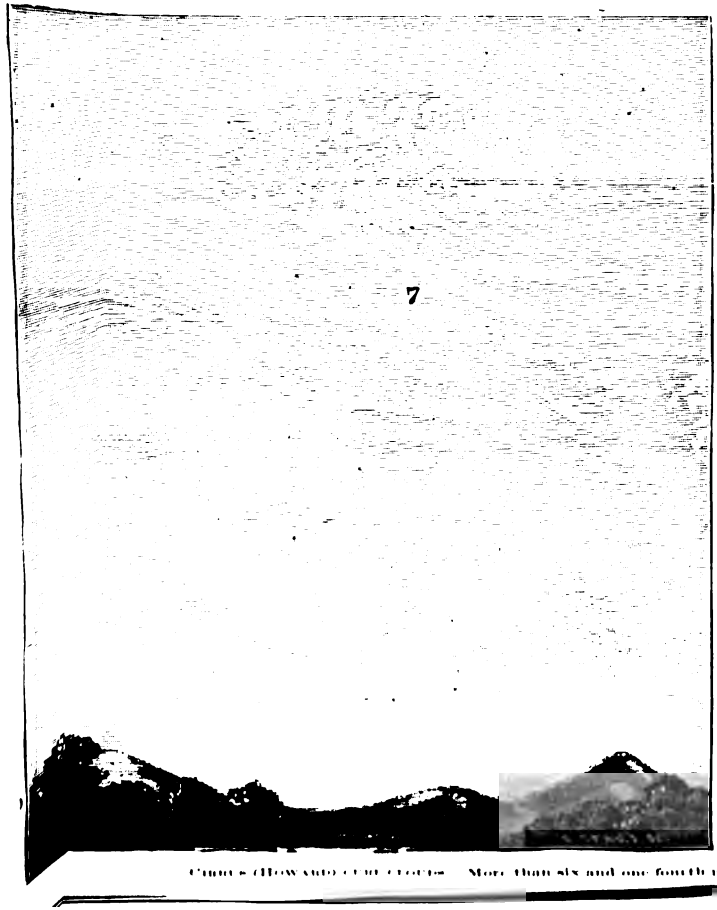
The nomenclature I have adopted appears more in accordance with the nature of clouds, for this reason, that the two types, *cirrus* and *cumulus*, are strictly based upon the constitution of *ice* and *snow* clouds and of clouds of aqueous vapor; while there is no proof of the existence of Howard's third type, since, according to this savant, it is a *mist* which overspreads the earth at sunset, but is raised in the morning at the first appearance of the sun. My nomenclature offers the same number of cloud forms; that is to say, seven, two types and five derivatives.

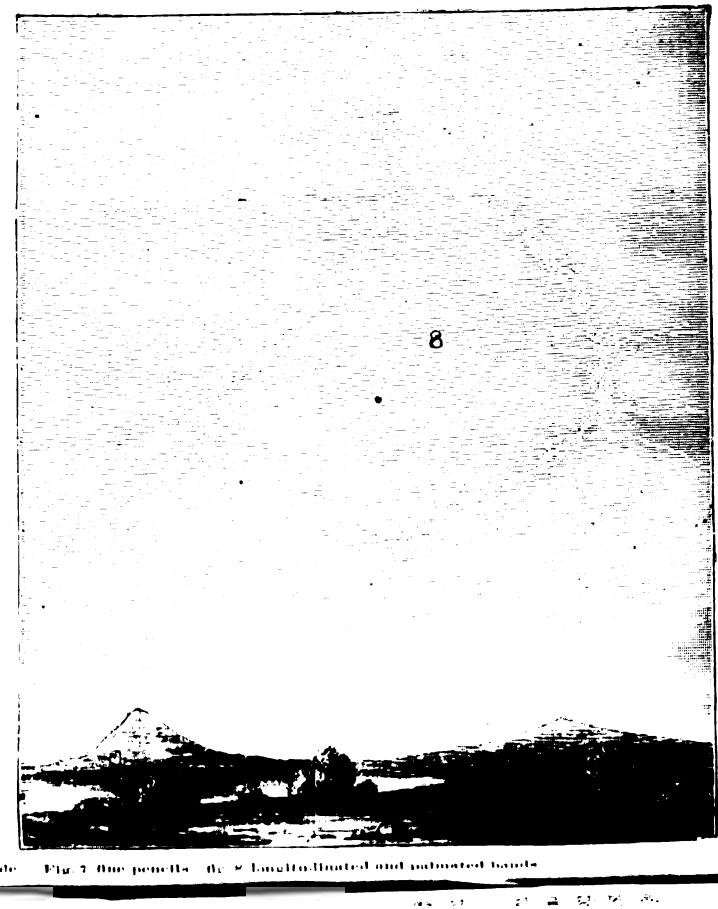
The order in which the clouds are placed in my table corresponds at the same time to the order of their appearance, from the highest regions

No. I. ILLUSTRATION OF CLOUDS. No. II.

CIRRUS (HOWARD) CURL CLOUDS.—More than six and one-fourth miles in altitude. Figs. 1 and 2, cat's tails; figs. 3 and 4, twisted tufts; fig. 5, plumage; fig. 6, horse's tail

No. III. ILLUSTRATION OF CLOUDS. No. IV.





Cirrus (Mare's tail) or curl clouds. More than six and one fourth miles in altitude. Fig 7 fine pencilly or Longitudinated and undulated bands

of the *cirrus* down to those nearest the earth where the *fracto-cumulus* is produced, as the vapor of water passes from the state of frozen particles to that of aqueous globules, or *vice versa*. However, the *pallio-cumulus*, which serves as a transition from the two types and their derivatives, is found a little more elevated than the *cumulus*.

I have thought it proper to modify Forster's nomenclature by substituting names more in harmony with the form and nature of clouds. I give, in continuation, the old and the new classification:

	Forster's nomenclature.	Poëy's nomenclature.
Cirrus	*Curl*-cloud	*Curl*-cloud.
Cirro-stratus	*Wane*-cloud	*Thread*-cloud.
Cirro-cumulus	*Sonder*-cloud	*Curdled*-cloud.
Pallio-cirrus		*Sheet*-cloud.
Cumulus	*Stacken*-cloud	*Mount*-cloud.
Pallio-cumulus		*Rain*-cloud.
Fracto-cumulus		*Wind*-cloud.

With the exception of cirrus, whose name *curl*-cloud approaches nearest the form of that cloud, all the determinations have been changed. The *pallio-cumulus* replaces the *nimbus*, also named *rain*-cloud.

I.—Cirrus, (Howard.)

Curl-cloud—cirrus, so named by Howard, (the "cat's-tail" of sailors, illustration No. I, figs. 1, 2,) is composed of filaments which resemble a twisted tuft of curled hair, (illustration No. I, figs. 3, 4,) plumage, (fig. 5,) the flowing tail of a horse, (illustration No. II, fig. 6,) or a fine pencil, (illustration No. III, fig. 7;) at other times are disposed in long, straight bands, parallel to each other, or divergent, palmated, or like a herring-bone or vertebral column, (illustration No. IV, fig. 8,) their greater axis oriented according to the sailing of the cloud and the direction of the wind at that altitude, which soon makes itself felt at the surface of the earth. When it forms two or more systems of straight, parallel bands, by an effect of perspective they appear to diverge from their point of departure at the horizon, and to converge toward the point of the horizon opposite, as do the rays of the rising and setting sun.

The cirrus is always white—sometimes brilliant, sometimes pearly-dull. The earliest and latest reflections of the solar rays upon these clouds color them with a delicate rosy tint, more or less intense, according to their density. Their movement is exceedingly slow, and their altitude is not less than 10,000 yards, (more than six and a quarter miles.) These clouds are the highest, apparently, slowest, most rarified, most variable in their forms, and the most extended. The appearance or disappearance of *cirrus* proclaims the end or the commencement of good weather. The barometer sinks and then rises, all the accompanying meteorological phenomena undergoing a similar change. We quote from Howard:

They are first indicated by a few threads penciled, as it were, on the sky. These increase in length, and new ones are in the mean time added to them. Often the first-formed threads serve as stems to support numerous branches, which in their turn give

rise to others. The increase is sometimes perfectly indeterminate; at others, it has a very decided direction. Thus the first few threads being once formed, the remainder will be propagated in one or more directions laterally, or obliquely upward or downward, the direction being often the same in a great number of clouds visible at the same time; for the oblique, descending tufts appear to converge toward a point in the horizon, and the long, straight streaks to meet in opposite points therein; which is the optical effect of parallel extension. The upward direction of the fibers or tufts of this cloud is found to be a decided indication of *rain;* the downward as decidedly indicates fair weather. Their duration is uncertain, varying from a few minutes after the first appearance to an extent of many hours, and even days. It is long when they appear alone and at great heights, and shorter when they are formed lower and in the vicinity of other clouds. This modification, although in appearance almost motionless, is intimately connected with the variable motions of the atmosphere. Considering that clouds of this kind have long been deemed a prognostic of wind, it is extraordinary that the nature of this connection should not have been more studied, as the knowledge of it might have been productive of useful results. In *fair* weather, with light, variable breezes, the sky is seldom quite clear of small groups of the oblique *cirrus*, which frequently come on from the leeward, and the direction of their increase is to windward. Continued *wet* weather is attended with horizontal sheets of this cloud, which subside quickly and pass into the *cirro-stratus*. Before *storms* they appear lower and denser, and usually in the quarter opposite to that from which the storm arises. Steady, high winds are also preceded and attended by streaks running across the sky in the direction they blow in.

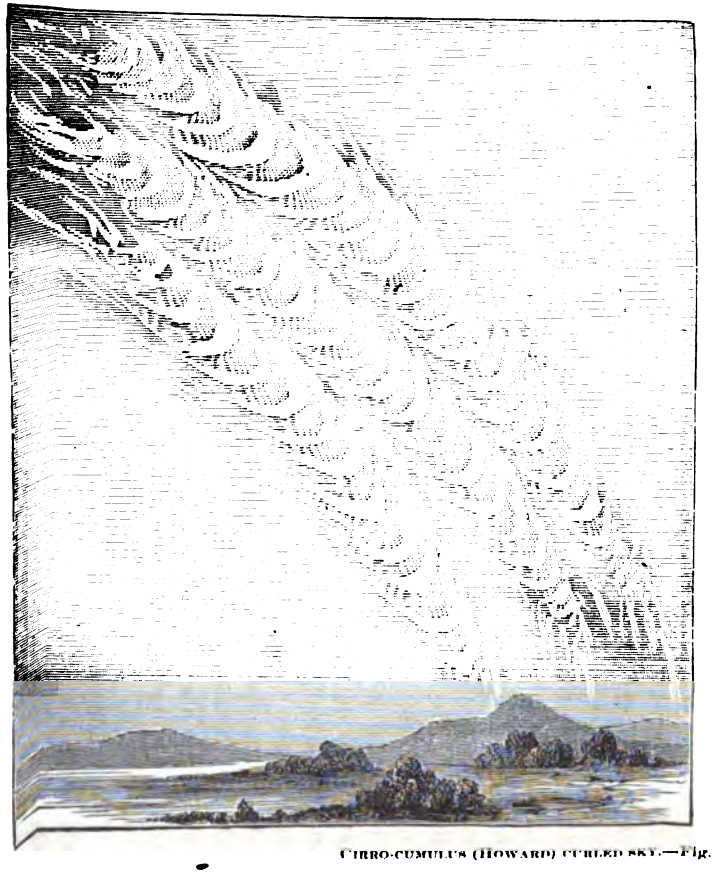
II.—CIRRO-STRATUS, (HOWARD.)

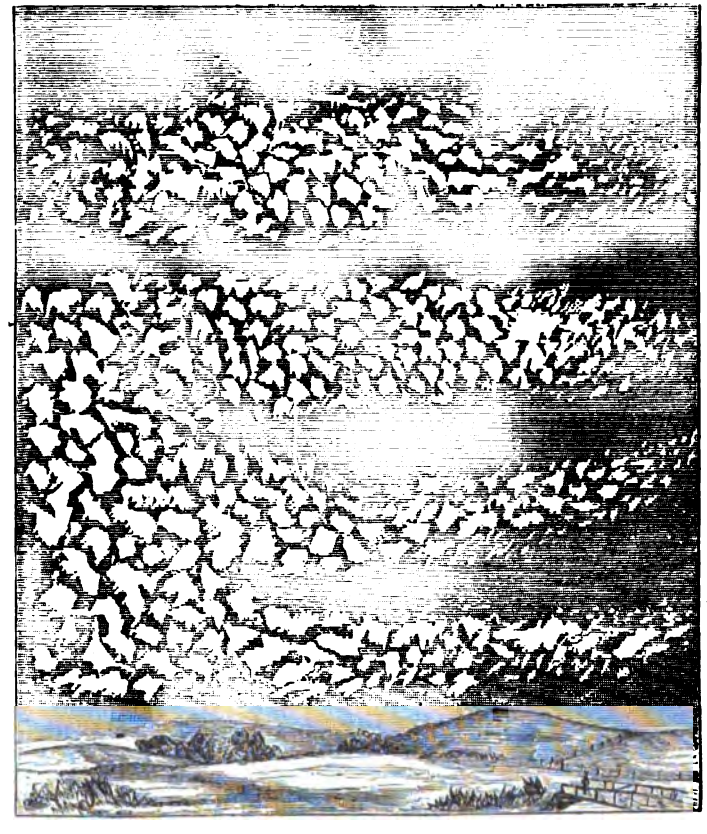
Thread-cloud, (illustrations Nos. V and VI.)—Howard's *cirro-stratus* is distinguished from the pure *cirrus* by its filaments being smaller, more compact, more ramified, and, so to say, completely stratified. They are lower and more dense, for the sun's rays often pierce them with difficulty. Their whitish tint is clearer, and it becomes rose-color in similar circumstances. Their motion is a little more rapid. When at the horizon, we only seeing the vertical projection, they take the appearance of a long and very narrow band. According to Howard, "this cloud appears to result from the subsidence of the fibers of the *cirrus* to a horizontal position, at the same time that they approach each other laterally. The form and relative position, when seen in the distance, frequently give the idea of shoals of fish. Yet in this, as in other instances, the *structure* must be attended to rather than the *form*, which varies much, presenting at times the appearance of parallel bars, or interwoven streaks like the grain of polished wood. It is thick in the middle, and attenuated toward the edge. The distinct appearance of a *cirrus*, however, does not always precede the production of this and the last modification. The *cirro-stratus* precedes *wind* and *rain*, the near or distant approach of which may sometimes be estimated from its greater or less abundance and permanence. It is almost always to be seen in the intervals of storms. Sometimes this and the *cirro-cumulus* appear together in the sky, and even alternate with each other in the same cloud, when the different evolutions which ensue are a curious spectacle; and a judgment may be formed of the weather likely to ensue by observing which modification finally prevails. The cirro-stratus is the modification which

No. V. ILLUSTRATION OF CLOUDS. No. VI.

[illegible] ion or cirrus.—a b c d e, partial formation. f, portion formation. a b c d e f g, nascent formation.

No. VII. ILLUSTRATION OF CLOUDS. No. VIII.





CIRRO-CUMULUS (HOWARD) CURLED SKY.—Fig. 1, perfect type; fig. 2, bizarre form; fig. 3, irregular form.

most frequently exhibits the phenomena of the solar and lunar halo, and (as inferred from a few observations) also the parhelion and paraselene. Hence the reason of the prognostic of foul weather, commonly drawn from the appearance of halo. The frequent appearance of halo in this cloud may be attributed to its possessing great extent at such times with little perpendicular depth, and the requisite continuity of substance. This modification is, on this account, peculiarly worthy of investigation."

III.—Cirro-cumulus, (Howard.)

Curdled cloud, (illustrations Nos. VII and VIII.)—It is sufficient that the *cirro-stratus* sinks a little, or that the temperature of the region it occupies be slightly elevated, in order to give birth to Howard's *cirro-cumulus*. In the first place, the axes of the *striæ* grow round; then, by degrees, the entire stratification becomes so, until it resembles carded cotton, which we call *frizzled* clouds or *curdled* sky; in French, when it is completely covered, *moutonnés* or *pommelé;* in Spanish, *cielo empedrado*. On the contrary, if the *cirro-cumulus* is elevated a little, or the temperature is lowered, it returns to the type of *cirro-stratus*.

The *cirro-cumulus* is more dense and lower than the *cirro-stratus*, from which it is derived, though generally the edges of the small accumulations or of the entire mass of cloud are transformed into *cirro-stratus*, wherever, from a greater elevation or a lower temperature, the congelation is more vigorous. Its motion is also more rapid, its color slightly grayish, and it may be tinged rose-color or rather reddish.

The *cirro-stratus*, and especially the *cirro-cumulus*, is remarkable from a characteristic of the highest importance, which has escaped the sagacity of Howard and his successors, viz, the distribution of congealed aqueous vapor. It exists in the most fantastical combinations, reproducing all the formations of our continents and seas. Here, a deep bay with promontories, capes, peninsulas, isthmuses, &c.; there, a river, brooks, lakes, &c.; farther on vast continents and open seas. The outlines and the entire mass of each of these are besprinkled with *cirro-cumulus*, sometimes edged with *cirro-stratus*, whose volumes of little balls diminish and vanish from center to circumference, while in the empty spaces is the purest azure of the heavens. (Plate.) Should it be a lake, the water will be represented by the blue sky, and *terra firma* by the *cirro-cumulus* which surrounds it. By carefully studying all these transformations, we can observe in them a striking analogy to the phenomena of the precipitation and congelation of dew. There must be at this altitude, in the same stratum, one above the other, portions of the atmosphere having different degrees of density and of temperature, in order that the congelation of aqueous vapor should take place in so variable a manner.

The influence of *cirro-cumulus* upon the temperature at the surface of the earth is so marked that the human body feels it at once. A *curdled* sky at the new moon, on a calm night in the tropics, is a sky compara-

tively glacial, an effect probably due to the nearness and the quantity of snow which compose this type of cloud.

The *cirrus* being much more elevated and the *cirro-stratus* much less abundant, although both formed of glacial aiglets, have not the same influence on terrestrial temperature. According to Howard, the *cirro-cumulus* is formed from a *cirrus*, or a number of small separate *cirrus* by the fibers collapsing, as it were, and passing into small, roundish masses, in which the texture of the *cirrus* is no longer discernible, although they still retain somewhat of their relative arrangement. This change takes place either throughout the whole mass at once, or progressively from one extremity to the other. In either case the same effect is produced on a number of adjacent *cirri* at the same time and in the same order. It appears in some instances to be accelerated by the approach of other clouds. This modification forms a very beautiful sky, sometimes exhibiting numerous distinct beds of these small connected clouds, floating at different altitudes. The *cirro-cumulus* is frequently seen in *summer*, and is attendant on warm and dry weather. It is also occasionally and more sparingly seen in the intervals of showers and in *winter*. It may either evaporate or pass to the *cirrus* or *cirro-stratus*.

IV.—PALLIUM, (POËY,) (vel *nimbus*, HOWARD.)

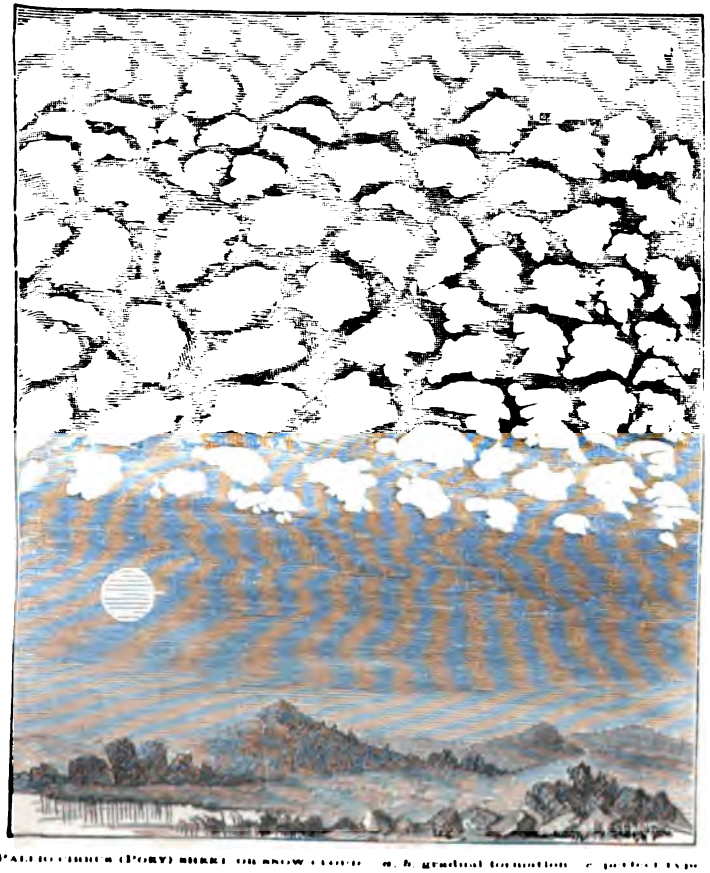
Under the generic name of *pallium* I have classed two forms of cloud, which present the appearance of a mantle or veil of considerable extent, of very compact texture, well defined at the edges, of excessively slow motion, and embracing the visible vault of the sky. As the *pallium* is formed of *cirrus* or of *cumulus*, it is distinguished into *pallio-cirrus* and *pallio-cumulus*. The appearance of this cloud signalizes bad weather, and its disappearance, good weather.

The stratum of *pallio-cirrus* is first produced, and some hours or days afterward that of *pallio-cumulus* is formed under it. These two strata remain in view at a certain distance from each other, and in their reciprocal action and reaction are accompanied with storms and heavy rains, and with considerable electric discharges. They are both electrified, but with contrary signs; the superior stratum of *cirrus* is negative, and the inferior one of *cumulus* is positive, the same as the rain which is disengaged, while the electricity of the air, at the surface of the earth, is negative. But when these two strata attract each other a discharge is produced, and the inferior stratum continues to pour out the surplus water it contained, without giving any sign of electricity, more than the air in contact with the earth. This state continues until the inferior stratum opens, afterward the superior, and then disappear, one after the other, fine weather succeeding. The *pallium* chiefly predominates during the rainy season, in tropical regions, and in the higher latitudes during winter, at the time of falls of snow. A part of the *pallio-cumulus*, which has not been reduced, or has not been scattered to other regions, gathers at the horizon, and is transformed into the cumulus. As to the

No. IX.

ILLUSTRATION OF CLOUDS.

No. X.



pallio-cirrus, it disappears entirely if fine weather is maintained. Let us now see what are the inherent characters of the two *pallio*.

V.—Pallio-cirrus, (Poëy.)

Sheet-cloud, (illustration No. IX.)—The *pallio-cirrus* is formed by the accumulation of a *cirro-cumulus*, which is visibly sinking, or appears already formed toward a point of the horizon in the stratum, corresponding to this latter type. In the first case it is a little lower, more dense, less compact, more rapid in its movement, grayish, and often shows some traces of polarization. In the second case it is a little higher, less dense, more compact, less rapid, pearly whitish, impenetrable to the solar rays, and without a trace of polarization. In the two cases it appears generally in the south-westerly horizon, showing the presence of the superior equatorial current, and determining the fall of rain while it remains above and opposite the *pallio-cumulus*. When a breach is made in this inferior stratum it is speedily produced in that of the *pallio-cirrus*; sometimes it has already been formed in the latter. After the rupture of this stratum, the *pallio-cirrus* is transformed into *cirro-cumulus*, studded with *cirro-stratus*. On the approach of *pallio-cirrus* we observe the following meteorological manifestations: the barometer falls, the thermometer rises, the relative humidity increases, the tension of vapor diminishes, and a little after the wind at the earth is felt from that direction.

VI.—Cumulus, (vel cumulo-stratus,) (Howard.)

Mount-cloud, (illustrations Nos. X and XI.)—Howard's *cumulus*, (or *cumulo-stratus*,) summer and aqueous vesicle clouds, (the "cotton-balls" of sailors,) always appear in the form of a hemisphere or arcs of a circle, and repose upon a horizontal base. When these hemispheres are piled upon one another, there are formed great clouds accumulated at the horizon, similar to mountains in the distance covered with snow. Their contours take many forms, human, animal, and of every kind, more or less *bizarre* and fantastic, which inspired the poet Ossian with his finest images, and have given rise in mountainous countries to many popular traditions.

When the *cumulus* moves along the horizon, it is, excepting *fracto-cumulus*, the most rapid of all clouds. But when it is piled up along the horizon, in summer toward the south, in winter toward the north, it is excessively slow, and remains a whole day scarcely moving. It then extends perpendicularly or obliquely toward the zenith. Its roundish summit is of a glittering whiteness, and when elevated high enough, it is dyed rose color morning and evening like the *cirrus*. The center of the cloud is grayish, the base slate color or black. The base of the *cumulus* always rests upon the horizon, and is little elevated during a storm. It follows the direction of surface winds. Upon the plateau of the valley of Mexico, the *cumulus* completely disappears during the winter half of the year, and appears anew during the other six months. In summer it appears about eight or nine o'clock in the morn-

ing. It attains its highest elevation from two to three o'clock in the afternoon, during the greatest heat, after which it fades away gradually, and a little after sun-down disappears entirely behind the hills. Thus *cumulus* in Mexico is only visible in summer and during the day. Howard says:

Clouds in this modification are commonly of the most dense structure; they are formed in the lower atmosphere and move along with the current which is next the earth. A small, irregular spot first appears, and is, as it were, the *nucleus* on which they increase. The lower surface continues irregularly plane, while the upper rises into conical or hemispherical heaps, which may afterward continue long nearly of the same bulk or rapidly grow to the size of mountains.

In the former case they are usually numerous and near together, in the latter few and distant; but whether there are few or many, their *bases* lie always nearly in one horizontal plane; and their increase upward is somewhat proportionate to the extent of base, and nearly alike in many that appear at once.

Their appearance, increase, and disappearance in *fair* weather are often periodical and keep pace with the temperature of the day. Thus they will begin to form some hours after sunrise, arrive at their maximum in the hottest part of the afternoon, then go on diminishing, and totally disperse about sunset.

But in *changeable* weather they partake of the vicissitudes of the atmosphere; sometimes evaporating almost as soon as formed; at others suddenly forming and as quickly passing to the compound modifications.

The *cumulus* of *fair* weather has a moderate elevation and extent, and a well-defined, rounded surface. Previous to *rain* it increases more rapidly, appears lower in the atmosphere, and with its surface full of loose fleeces or protuberances.

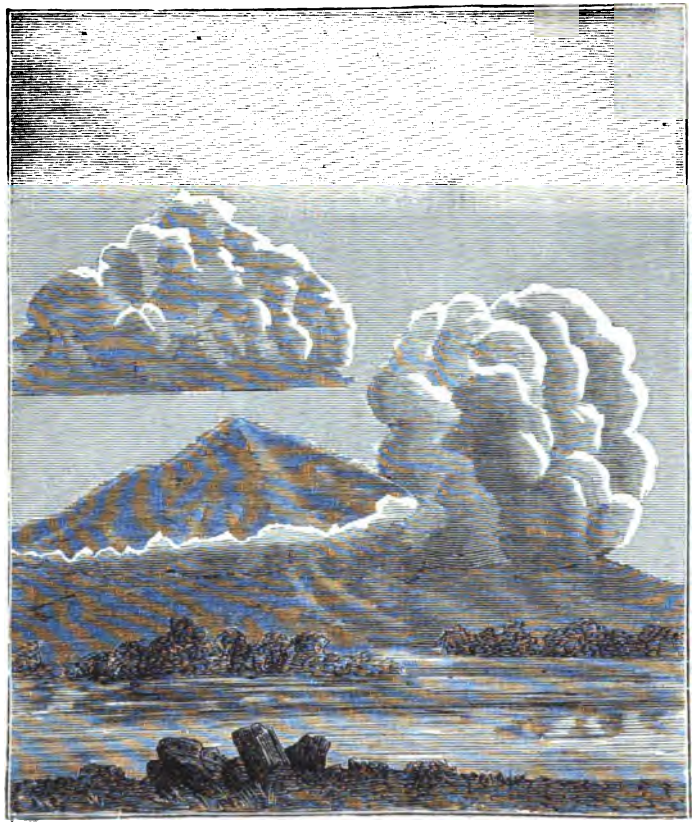
The formation of large *cumulus* to leeward in a strong wind indicates the approach of a calm with rain. When they do not disappear or subside about sunset, but continue to rise, thunder is to be expected in the night.

Independently of the beauty and magnificence it adds to the face of nature, the *cumulus* serves to screen the earth from the direct rays of the sun; by its multiplied reflections to diffuse, and, as it were, economize the light, and also to convey the product of evaporation to a distance from the place of its origin. The relations of the *cumulus* with the state of the barometer, &c., have not yet been enough attended to.

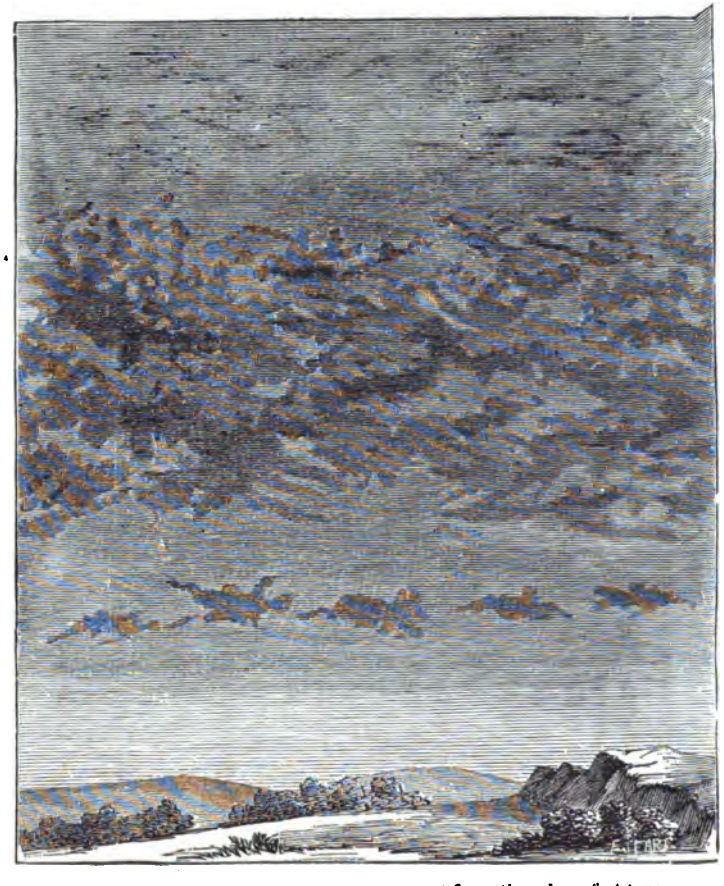
VII.—PALLIO-CUMULUS, (POËY.)

Rain-cloud, (illustration No. XII.)—The *pallio-cumulus* is produced by the accumulation of *fracto-cumulus*, which is gradually extended under the form of a uniform and compact stratum. This stratum is constantly sustained by the entrance of new *fracto-cumuli*, which increase its thickness until rain begins; then the *fracto-cumulus* ceases to penetrate it, and passes along the stratum of *pallio-cumulus*, but before the end of the rain it is disengaged anew from the stratum, which grows thin, is broken up and disappears. The *pallio-cumulus* is lower, more dense, less compact, more rapid than the *pallio-cirrus*, and is slate-colored or grayish. The thicker and more compact this stratum is, the longer will the rain continue; but as soon as a breach is made, it disengages fragments of *cumulus*, (*fracto-cumulus*,) which rapidly disappear, while the remainder are piled up at the horizon in the form of *cumulus*. The *pallio-cumulus* appears almost always from the northeast, showing the inferior polar current, which soon reaches the surface of the earth. The meteorological manifestations determined by them are inverse to those of *pallio-cirrus*; the

No. XI. ILLUSTRATION OF CLOUDS. No. XII.

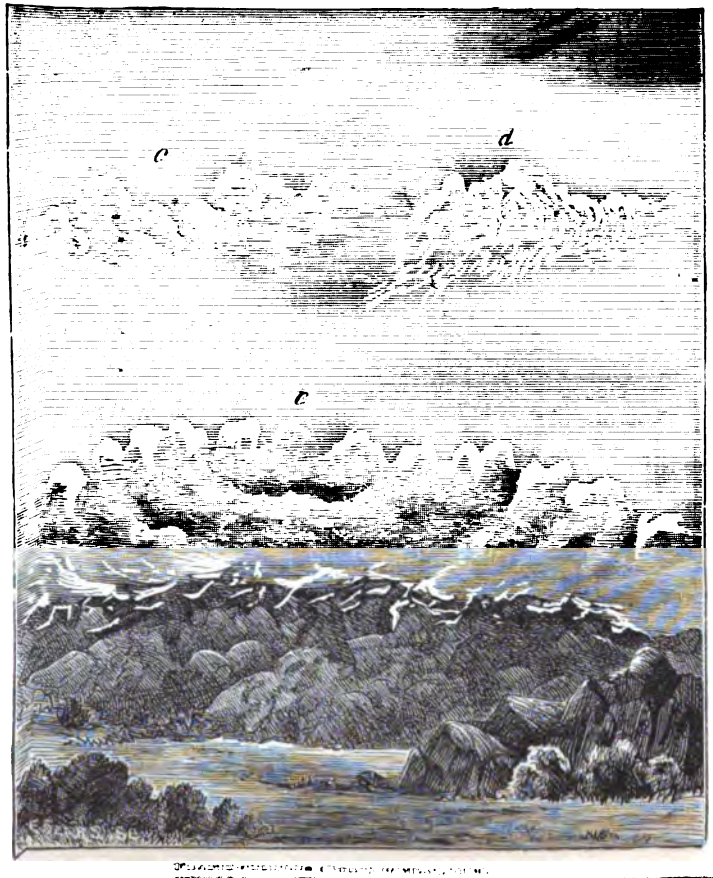


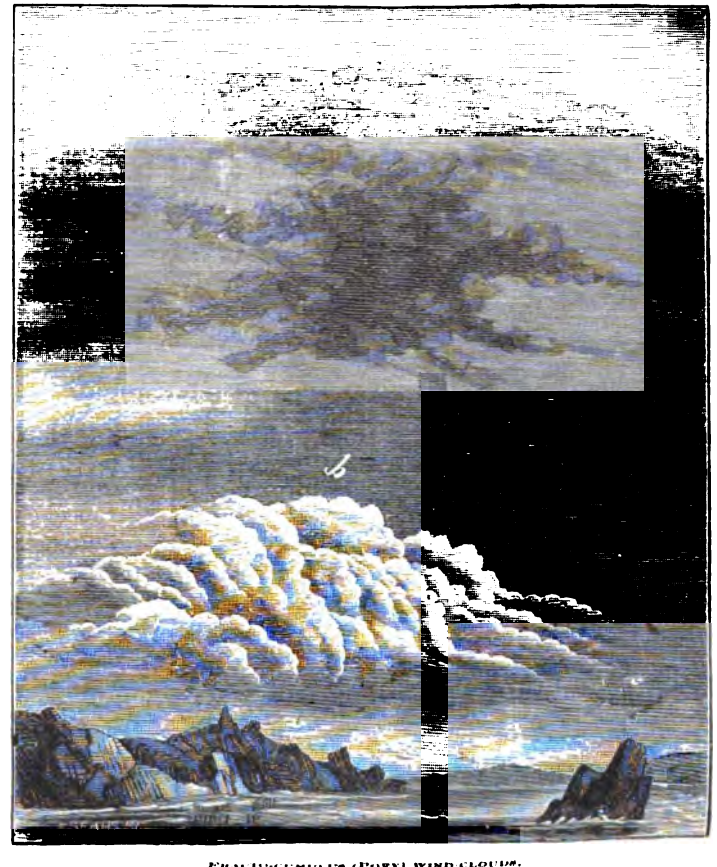
CUMULUS (NEL-CUMULO-STRATUS) MOUNT-CLOUD.—*b. b.* nascent formation.



PALLIO-CUMULUS (POEY) RAIN-CLOUD.—*a*, nascent formation; *b*, perfect type.

No. XIII. ILLUSTRATION OF CLOUDS. No. XIV.





PRACTICE-CLOUDS (PORY) WIND CLOUDS.

barometer rises, the thermometer falls, the relative humidity diminishes, and the tension of aqueous vapor increases.

VIII.—FRACTO-CUMULUS, (POËY.)

Wind-cloud, (illustrations Nos. XIII and XIV.)—The clouds which I have denominated *fracto-cumulus* are isolated fragments of *cumulus*, more or less considerable, without determinate form, jagged at the edges, the lowest and most rapid of all, and whitish, grayish, or slate-colored, according to their density. As soon as an invisible storm has broken out in the distance, we see them moving with great rapidity, almost grazing the highest buildings and tallest trees; their borders are greatly torn and white, contrasting strongly with the grayish stratum of superior *pallio-cumulus*. They are visible day and night, and often traverse the firmament from northeast to southwest without interruption for many days, while the sky above and in the intermediate space is perfectly clear. In winter we see them alone under a blue sky, sending in their passage to the zenith interrupted showers of rain, accompanied by strong gusts of wind, which occasion a very slight elevation and oscillation in the barometric column. In the Antilles these clouds produce the disagreeable winter rains, and in Europe the March storms. They generally follow the direction of the wind prevailing at the surface of the earth. When this wind is contrary to the direction of *fracto-cumulus*, it soon takes the same course.

A little before a storm or tempest arises, there appear a series of very small *fracto-cumuli*, which move rapidly, almost to two-thirds of their height, along a considerable mass of *cumulus*, which is stationed very often, as if immobile, near the southern horizon. Soon these *fracto-cumuli* become more abundant, less rapid, and form a horizontal band, which cuts the *cumuli* near their summit. This appearance is a warning sign for sailors, as it announces a squall. In fact, the *fracto-cumuli* become more and more developed; an exchange of opposite electricities takes place between them, and the storm quickly arises. It is, therefore, the same little cloud, of which I have spoken above, that, returning then from the combat, comes now to offer new battle. The aggregation of *fracto-cumulus* forms the *pallio-cumulus*, and increases and constantly maintains this stratum.

NATURE OF THE CLOUDS DEDUCED FROM THE FORMATION OF HALOS, CORONAS, AND RAINBOWS.

We can further distinguish the nature of clouds by the optical phenomena to which they give rise, according as their intimate constitution is more or less connected with a certain degree of aqueous vapor, in the state of snowy or glacial congelations of the strata corresponding to the formation of each type. The following are some facts which I have observed at Havana, which it is important to verify in other regions:

Generally speaking, *cirrus*, more especially *pallio-cirrus*, gives rise to a large solar and lunar halo of 22° radius. When it is produced by the

sun, it sometimes presents the seven colors of the spectrum, although usually there is only a single internal tint of orange, terminating at times in a little red. On the contrary, the great halo produced by the moon is almost always white, and seldom exhibits the tint of orange without the red.

The *cirro-cumuli* produce the lunar halo of about 2° to 4° radius, which may be triple or formed of sixteen prismatic rings with an internal tint of red. This halo is still more brilliant when it takes place, rarely enough, with *cirro-stratus*.

The *fracto-cumuli* are the only clouds which do not produce halos, but they do produce complete coronas or segments of arcs, according to the extent of the fragments which traverse the lunar disk. These coronas are also prismatic, having a blue interhal tint.

The *pallio-cumulus* and the *cumulus* form neither halos nor coronas, but solar and lunar rainbows. In fine, aqueous vapor extremely dissolved, elastic, uniformly distributed in the higher regions of the atmosphere, without much altering the transparency of the air, gives rise to the formation of a *little* halo. Their unique coloration, in *brown* or *russet*, light or dark, as well as their size, is intimately connected either with the density of aqueous or elastic vapors or their altitude; their dimensions may vary from the borders themselves of the lunar disk up to 2° radius. We find them in every lunation.

QUANTITY OF CLOUDS.

We measure by the eye the blue vault of the sky, or the quantity of visible clouds, which can then be determined according to a conventional scale in decimal fractions from zero (0) to unity, (1.) But it is preferable to take directly the quantity of clouds, and to repeat this calculation for each quadrant, upon each stratum and upon each type, instead of restricting ourselves to the *ensemble* of the sky, paying no attention to their nature, as has been hitherto everywhere done.

Here is the mode of proceeding: We explore the first quadrant, and if we find three different types of clouds—for example, the *cirrus* elevated, *cumulus* at the horizon, and *fracto-cumulus* low and isolated—we judge one after the other, according to their extent in height and breadth, the space which they occupy relatively to the 90° comprised from north to east, and from the horizon to the zenith of this quadrant. We then write for example in the corresponding columns 0.4 *cirrus*, 0.3 *cumulus*, and 0.2 *fracto-cumulus*. If the quadrant examined is completely covered by a single cloud, we mark unity, (1,) and its corresponding type. If, on the contrary, there is no cloud, we place 0. We repeat in turn the same operation in the three other quadrants, from southeast, from southwest, and from northwest.

At times the quantity of clouds associated with others of a different nature is so small, consisting merely of fragments, that it would be extremely difficult to make a just calculation, and then we mark *isolated*

No. XV. ILLUSTRATION OF CLOUDS. No. XVI.

CIRRO-CUMULUS-STRATUS, (POEY.)—*a*, ice and snow clouds.

(Observed only in Cuba in 1864.)

CIRRO-STRATO-CUMULUS, (POEY.)—*b*, ice and snow clouds.

cloud of the corresponding type. During a continuous rain, when the sky is completely covered with a *pallio-cumulus*, we are sure to find above it a second stratum of *pallio-cirrus*, which occasions this rain. So after this examination we write in each quadrant unity for these two types. But as soon as a breach is made in the stratum of *pallio-cumulus*, then care must be taken not to confound the quantity of cloud corresponding to each of these two strata, which are perceived one after the other. With a little attention we come perfectly to know each order of cloud and the space it occupies.

DIRECTION OF THE CLOUDS.

We should note in another column the direction of each type of cloud corresponding to the first sixteen cardinal points of the compass. For this purpose, we must observe the space whence the cloud sets out, and that of the opposite horizon, where it is lost. When the cloud traverses the zenithal region, the observation can be easily made. There is only a single position which can give rise to error by an effect of perspective, which takes place morning and evening, when the *cumuli* are not removed from the limits of the horizon, where they have a very slow march and disappear at the opposite side in the same parallel plane. We think then that a cloud freely sets from east to west, or *vice versa*, either by the north or by the south, when it has rather an inclination from northeast, from northwest, from southeast, from southwest, or any other. If it is at sunrise or sunset, if the wind is from east to west, or if the vane remains stationary in one of these directions, we may be certain that the *cumulus* pursues this horizontal course perpendicularly to the meridian.

Often it is very difficult to grasp the direction of *cirrus*, because of its extreme slowness, and the considerable quantity and great extent of its filaments, which are oriented on every side. The attention must be principally fixed upon the side of the displacement of the ridge or central trunk whence this multitude of bands and lateral filaments is detached. The march of *cirrus* is then almost always in a longitudinal plane or parallel to the longer axis. By a law of perspective, the parallel bands appear to diverge from a point of the horizon, and on the other hand to converge toward another point diametrically opposite; but the observation of the point of convergence on the opposite horizon will give the mode of orientation.

There is another optical illusion, against which we must especially guard, in order not to commit a very grave error; for it appears each time that below a stratum of superior and very slow *cirrus*, we perceive a second stratum of inferior and rapid *cumulus*. In this case the *cirrus* seems to march rapidly in the opposite direction to that of the *cumulus*, when, in reality, it is following the same path, but more slowly. It is an illusion analogous to that remarked in a railway carriage when the objects closer to us file rapidly past in a direction contrary to that of the

locomotive; while objects more removed, beyond the second plane, move in the same direction. We cannot caution observers too much against this error, especially when there are three or four strata of superposed clouds, some having the same direction, and others opposite ones.

Very often, also, the *cirri* are so slow that it must take many hours to comprehend their march. This extreme slowness contributes to a lateral movement perpendicular to their advance still more pronounced than that of the *cumulus* or other types of clouds; to this must be added their filamentous form and the great number of their ramifications. In this case the observer must take a bench-mark upon some elevated structure in the city or the summit of a mountain or top of a tree, verifying it from hour to hour, and if these precautions are not yet sufficient, wait until the *cirrus* has passed the meridian or disappeared at the opposite horizon. Generally, at the observatory at Havana, the direction of *cirrus* is definitely noted upon the register only in the afternoon, although it has appeared at five or six o'clock in the morning.

When a *cumulus* is swelling up from a base below the horizon toward the zenith it presents the appearance of a motion which must be distinguished from the true direction of the cloud.

Cirrus, *cirro-stratus*, and *cirro-cumulus* come generally from the southwest, showing presence of the superior *equatorial* current.

Cumulus, *cumulo-stratus*, and *fracto-cumulus*, on the contrary, appear toward the northeast, determining the inferior *polar* current. But the *cumuli* from June to December generally take a middle direction, from the east, under the influence of the northeast and southeast trade-winds, while the *fracto-cumulus* accompanies the polar current from the northeast, from December to May, when this last, going against the current from southeast of the southern hemisphere, draws near the equator and causes the trade-winds to descend from north to east-northeast, or east.

Moreover, the *pallio-cirrus* and the *pallio-cumulus* serve alternately as a transition between these two opposite currents, the *equatorial* and *polar*, although the first type accompanies more frequently the superior current and the second the inferior current; so that these two *pallia* alternate in the following order:

Cirrus, Cirro-stratus, Cirro-cumulus.	Superior equatorial current.
Pallio-cirrus.	
Pallio-cumulus.	
Cumulus. Fracto-cumulus,	Inferior polar current.

VELOCITY OF CLOUDS.

Our present uncertainty as to the velocity of clouds, the difficulties which are presented to a single observer, perhaps, deprived of sufficient knowledge or suitable instruments to undertake directly this calculation,

makes it only possible to determine it visually and approximately. As a general rule, clouds appear more rapid the nearer they are to the surface of the earth, and slower the farther they are removed from it. Therefore, the *fracto-cumulus*, which almost grazes the summits of mountains and tops of trees, is more rapid; while the *cirrus*, which is found in the torrid zone with an altitude of at least 10,000 to 15,000 meters, (six and one-fourth to nine and three-eighths miles,) is the slowest, seeing that it remains for hours at a time almost immovable.

We adopt the four following terms: *Slow, very slow, rapid, very rapid*, which suffice to express, with sufficient exactness, all velocities of clouds, because there is no case where we need a more minute nomenclature. The absolute determinations, especially *very rapid*, being the most difficult to seize, we must guard against making use of them before we are perfectly acquainted with the march of the *cirrus*, which loiters for hours, describing a little arc, and that of the *fracto-cumulus*, which has variable velocities. But after a few appearances of clouds with high velocity, the observer will be able to judge them correctly.

AZIMUTHAL ROTATION OF CLOUDS.

In a note presented to the French Meteorological Society, May 10th, 1864, I showed, from 280,320 observations made at the observatory of Havana, that the law of the rotation of winds formulated in 1827 by M. Dove is perfectly applicable to clouds, and it is this same rotary direction which determines the rotation of the inferior winds, and modifies all the meteorological phenomena; in a word, that meteorology must be taken *from above*, according to the profound remarks of M. Biot, at the French Academy of Sciences.

M. Dove's law of the change of winds may be thus recapitulated: 1. When in the northern hemisphere, currents of air coming from the equator, alternate with polar currents, the wind makes the tour of the compass oftenest in the order south, west, north, east, and south. 2. In the southern hemisphere it is the reverse, south, east, north, west, and south. 3. The influence of the wind upon meteorological phenomena, combined with this law of its change, shows two parts of the compass, opposed in all respects, the region of the east and that of the west, where the atmospheric variations offer a correspondence with the instruments, which it is easy to understand. We see, therefore, that this important law of M. Dove can assist us in *scientific prevision*, if we add M. Buys-Ballot's method of *ecarts*, which consists in taking the difference between the highest and lowest standing of the barometer, thermometer, &c.

Now, if the change of clouds, from *cirrus* to *fracto-cumulus*—that is to say, from an altitude of at least 10,000 meters to the surface of the earth—really obeys the same law as the change of winds, then our previsions acquire a greater degree of certainty.

In 1863 the wind at Havana completed twenty-three rotations, conjointly with *cumulus;* these latter, twenty-five rotations; *cirro-cumulus*

eighteen, and *cirrus*, seventeen. Two rotations, from 29th of June to 19th of October, were not accompanied with those of the wind.

Sometimes we find that all the strata of clouds, up to the *cirrus*, complete their rotation at the north on the same day and at the same hour. At other times, and these are the most numerous, the wind gains upon the *cumuli*, these on the *cirro-cumuli*, and these latter on *cirri;* that is to say, from below upward instead of from above downward, as before their rotation. This fact seems to contradict the hypothesis that the superior currents determine gradually the inferior currents. This, however, is owing to the fact that the currents are inclined, forming very nearly an angle of 45° with the surface of the earth, so that they are first felt at a point more to the north, falling by degrees until they attain all the points of their journey toward the south, through which they have passed above, till their extinction naturally, or by the shock of opposite currents. This appearance of the inferior current before the superior is especially frequent in low regions. It is presented five times against four between the wind and *cumulus*, and four other times simultaneously. In the higher regions, six times to five, the *cirro-cumulus* appeared before the *cirrus*, and in three other cases at the same time. The *cumuli*, in their turn, gained eleven times against two upon the *cirro-cumuli*, and twice again they happened at the same time.

By reason of the opposition or inversion of temperature between land and sea, the wind tends toward the south in the evening, and in the morning toward the north. The influence of these local movements of the breeze is such, in the general circulation, that it may retard the rotation of the wind, which terminates at the north, not only many hours, but besides from 90° to 180° in azimuth. The action of the sea-breeze seems to be more considerable than that of the land-breeze; but the breezes are much less sensible upon the *cumulus* and *cirro-cumulus*, especially when these latter are elevated, and they do not seem to reach the region of the *cirrus*. The continuance of each rotation varied considerably in 1863, as follows:

	Days.	Hrs.		Days.	Hrs.
For the *cirrus*, from	5	5	to	49	11
For the *cirro-cumulus*, from	3	8	to	62	5
For the *cumulus*, from	3	3	to	36	22
For the wind, from	4	0	to	71	9

The month of July did not present a single rotation of any of these four elements. It should be remarked that the greater number of the wind's rotations are accompanied by another rotation in the *cumulus;* that those of *cirro-cumulus* are more rare and less corresponding with the first; and that, in fine, those of *cirrus* are still further removed. It also appears that the rotations are less frequent in the higher regions than at the surface, and that the first of the *cirrus*, due to the equatorial current, are borne rather to the west, and especially to the southwest; while the second of the *cumulus*, arising from the polar current, are confined more to the region of the east, from north to southeast.

Whatever may be the regularity presented by the circulation of the winds, and of the clouds in the tropics, and whatever care, also, is taken in studying it, this circulation is not yet exempt from perturbations which mask a little the precise moment of the beginning and end of each rotation. The southeast trade-winds, and the configuration of the ground, are among the number of general disturbing causes; while the land and sea breezes, the cloudiness of the stratum of *cumulus*, which is more or less time prolonged, and covers that of *cirro-cumulus*, or these latter that of *cirrus*, their inclination in space, and consequently their transformation accidental and sudden, constitute the local disturbing causes.

I surmise, besides, the existence of great annual rotations produced by the earth's motion of translation in its orbit analogous to those produced by the rotation of the earth on its axis, both classes of rotation belonging to each climate of the terrestrial zones, having regard to the distribution of continents and seas, and to their physical constitution. These annual rotations appear to commence and terminate at the north; for the *cirrus* in October, for the *cirro-cumulus* in November, for the *cumulus* in December, and for the wind in January. According to this, the superior current employs a month in accomplishing its rotation from stratum to stratum, continually approaching the surface of the earth, and three months in reaching it.

Lieutenant Maury claims that the trade-winds are so *constant* and *uniform* that their direction no more changes than the current of the Mississippi. I do not share the opinion of this *savant*, for the observations at Havana demonstrate, on the contrary, that the north trade-wind varies from northeast, and sometimes north-northeast, up to east-northeast, chiefly from December to May, the time at which the current, from the northern hemisphere appears to be stronger than that from the southern, and consequently it approaches the equator. In the second part of the year, from June to November, the south polar current, being more intense, drives back the first, and advances to the latitude of Havana, and probably to the parallel of 30° north, the trade-wind then varying from east-northeast to southeast; so the limit of the displacement in latitude of the trade-winds depends more particularly on the respective intensity of the polar currents of each hemisphere. We see, therefore, that the time of appearance which I have established for *fracto-cumulus* and *cumulus* seems to correspond with the displacement of the trade-winds.

In fine, it is at the moment when the rotations of the wind and of *cumulus* correspond toward the southwest with that of the equatorial current that storms and great showers have generally taken place, in presence of a compact stratum, and a condensation of superior *pallio-cirrus*, and another stratum of inferior *pallio-cumulus*. But as soon as the wind and the *cumulus* revolve to the west, the storm begins to clear off, and the barometer rises. When these first two rotations terminate

at the north, the weather is completely reëstablished. The stratum of *pallio-cumulus* opens up, is broken, and continues thus to chase from the southwest; then it revolves, in turn, toward the north, in order, later, to commence a new rotation. The second stratum of superior *pallio-cirrus* proceeds in like manner, and disappears also.

Such are the principal facts concerning the azimuthal rotation of the winds and clouds, and, in general, of the diverse questions which have been treated in the course of these summary *instructions*, on which it is of the highest importance to fix the attention of observers in all parts of the world. Indications analogous to those which the observations made at the observatory of Havana have furnished us, should they be contradictory under identical latitudes, either by reason of the difference in longitude, or by the difference in the topography of the countries explored, will not be the less important on this account, and they will conduct us to a true conception of *atmospheric circulation* altogether, by putting us on the track of rational and scientific previsions.

ON THE EVAPORATION OBSERVED AT PALERMO IN 1865 AND 1866.

By P. Tacchini.

[*Translated for the Smithsonian Institution from the Meteorological Bulletin of the Royal Observatory of Palermo.*]

Evaporation is one of the most important elements bearing upon climatological relations, but one which, until now, has been little studied. In Italy there are some few stations in which such observations are conducted, although by different methods. In the determination of this element many difficulties and anomalies present themselves, insomuch that it is regarded as the least certain of all the problems offered by meteorology. Yet the instruments devised for the measurement of evaporation have been of late greatly improved, and in our opinion that of Vivenot is to be regarded as among the best. In our observatory the evaporation is observed simultaneously with two atmometers, one of which, being that of Gasparin, is entirely exposed to the direct action of the air and the solar rays; the other, that of Vivenot, is stationed with the other instruments of meteorology, designed for the temperature and humidity, that is to say, is defended from the direct action of the wind and sun. These two atmometers were described in our Bulletins Nos. 1 and 4 for 1865. The series of observations which we are about to present extends through twenty months, from May, 1865, when a commencement was made with the atmometer of Vivenot, to December, 1866, inclusive. This interval is undoubtedly too short for arriving at definitive conclusions; but on a comparative examination of the curves of evaporation with those of the other meteorological elements, we have always observed a constant relation, especially in regard to the temperature, force of the wind, and humidity, as may be verified by the monthly reviews. In consequence of this, I propose to determine these relations from the observations made, that is, to seek an expression for the evaporation in functions of those elements, whence a first approximation may be obtained, serving as a contribution on our part to the researches on the climate of Italy.

[We are unacquainted with the atmometer of Vivenot; that of Gasparin consists of a shallow vessel of tinned copper, one meter square, and fifty centimeters in depth. In one corner of this is a fine screw placed perpendicularly, with a micrometer head at the top, and a fine point at the bottom, by means of which a small fractional part of a millimeter of the depression of the surface of the water can be estimated. It is also furnished with a maximum and minimum thermometer, the bulbs of each being sheltered from the direct rays of the sun, while they partake of the temperature of the surface of the water. This apparatus is freely exposed to the open air and sunshine. Care is required that no water is allowed to fall into the vessel from rain, or if it does fall in, to allow for the quantity.—J. H.]

Table of the elements which have been employed in the researches on evaporation, as observed with the Vivenot atmometer, transcribed from the monthly bulletins.

Months.	Temperature.	Humidity.	Force of the wind.	Daily evaporation.	Total evaporation of the month.
1865.					
May	+20.5	68.9	7.4	3.394	105.215
June	23.5	63.5	11.2	4.719	141.581
July	26.0	64.3	9.7	5.113	159.082
August	26.7	64.7	6.9	5.268	164.008
September	23.4	67.3	9.2	4.329	128.921
October	20.3	75.5	10.9	2.746	85.132
November	15.9	69.0	9.0	2.790	83.730
December	12.3	73.3	8.0	2.151	66.688
1866.					
January	11.6	75.0	8.9	2.492	77.240
February	14.0	71.4	9.2	2.819	84.720
March	15.2	64.6	11.3	3.906	121.080
April	16.7	67.1	8.2	3.847	115.410
May	18.9	66.9	6.5	4.239	131.411
June	22.5	71.8	5.4	4.432	132.960
July	26.1	63.7	9.8	6.905	214.047
August	25.0	66.0	7.9	5.918	183.460
September	23.4	72.3	4.4	4.089	122.752
October	20.0	70.6	5.4	3.493	108.285
November	15.9	68.9	7.6	3.211	96.318
December	12.9	73.0	9.2	2.314	71.740

From the above table it will at once be perceived that the prime productive cause of evaporation is the temperature, the action of which may be promoted by the force of the wind and impeded by the humidity. If, therefore, we consider the quantity of evaporated water in relation alone to the temperature as the sole cause, we may deduce the equation—

$$390.8\ t = 78.175$$

whence—

$$t = +\ 0.20004$$

If then the heat alone were the evaporating force, by multiplying the mean daily temperature by the coefficient we should have the quantity of the evaporation in millimeters. By making this calculation for the months from the preceding table, and considering the differences between the observation and the calculation, it will be seen that, in 1865, the greatest differences are met with in the months of May and October, in which there occur two maxima of humidity, and that at that time the evaporation observed is less than that calculated; and, in 1866, the greatest differences are observed in the months of March, July, and August, in which there occur minima of humidity and an increase in the force of the wind, so that the observed evaporations become in these months greater than those calculated. Hence the influence of the force of the wind and of the humidity of the air is manifest. Taking account

then of the three elements, temperature, humidity, and force of the wind, we establish with the data of the table, for the daily evaporation, 20 equations of condition, which being resolved by the method of least squares yield the following normal equations:

$$\left.\begin{aligned} 8.10\,.\,t + 26.78\,.\,h + 3.22\,.\,f - 1.63 = 0 \\ 26.78\,.\,t + 95.93\,.\,h + 11.45\,.\,f - 5.33 = 0 \\ 3.22\,.\,t + 11.45\,.\,h + 1.45\,.\,f - 0.65 = 0 \end{aligned}\right\} \quad \cdots\cdots (1.)$$

wherein t, h, f, are the coefficients of the temperature, humidity, and force of the wind, to be determined. The equations (1) being resolved, we obtain the following values:

$$t = + 0.20675$$
$$h = + 0.01517$$
$$f = + 0.11006$$

which coefficients indicate that with the increase of the temperature and force of the wind, the evaporation also augments, while it diminishes with the increase of the humidity, which, in effect, is also shown by the actual review of each month. The formula, then, of the evaporation, by the Vivenot atmometer placed in the shade and defended from the direct action of the wind, will be the folowing:

$$E = T\,.\,0.20675 - H\,.\,0.01517 + F\,.\,0.11006$$

in which T indicates the temperature in centesimal degrees, H the humidity in hundredths of saturation, F the horary velocity of the wind in kilometers. If, with this formula, we calculate the daily evaporation for each of the twenty months under consideration, we obtain the following figures, which we transcribe, beside those resulting from observation, with the relative differences:

Months.	Evaporation calculated.	Evaporation observed.	Difference.
1865.			
	Millimeters.	*Millimeters.*	*Millimeters.*
May	4.024	3.394	— 0.630
June	5.144	4.719	— 0.425
July	5.485	5.113	— 0.372
August	5.317	5.268	— 0.049
September	4.847	4.329	— 0.518
October	4.269	2.746	— 1.523
November	3.246	2.790	— 0.456
December	2.257	2.151	— 0.106
1866.			
January	2.255	2.492	+ 0.237
February	2.839	2.819	— 0.020
March	3.320	3.906	+ 0.586
April	3.374	3.847	+ 0.473
May	3.624	4.239	+ 0.615
June	4.177	4.432	+ 0.255
July	5.526	6.905	+ 1.370
August	5.054	5.918	+ 0.864
September	4.244	4.089	— 1.155
October	3.696	3.493	— 0.203
November	3.094	3.211	+ 0.117
December	2.574	2.314	— 0.260

Hence it would appear that if the daily evaporation be calculated in this way we incur the risk of an error of $\pm$ 0^{mm}.6; and although this difference may seem considerable, yet, taking into account the small number of observations, and the anomalies which ordinarily occur in this element, as well as the excesses of the weather experienced in the two years of the observations, it will be seen that the variations in the evaporation are distinctly represented.

If the daily mean be thus calculated from the total of the twenty months, with T = 19°.54, H = 69.13 and F = 8.31,

It will be found	=	3^{m}.913
And the mean of the observed evaporation		3^{m}.924
Difference	=	0^{m}.011

So that the total of the calculated evaporation for the twenty months is found	= 2386^{m}.93
While that from observation	2393^{m}.78
Whence the difference	= 6^{m}.85

As a proof of the manner in which this formula may represent the course of the daily evaporation, we have calculated it for each day of the month of October, 1866, selecting this month for its variety in the different elements, so that the evaporation does not proceed directly in accordance with any of the curves of these elements.

The sum of the daily evaporations calculated for every day of this month gives a total of	113^{mm}.34
While the observed amount was	108^{mm}.29
Whence results a difference only of	5^{mm}.05

And from the course of the evaporation we have constructed the curves of evaporation as observed and calculated, which will be found in the annexed table, and which clearly demonstrate their conformity; thus proving the distinct exactness of the formula and the excellence of the instrument in its sensibility to the variations of the different elements which concur in the production of evaporation.

It is not at present possible to establish the exact ratio of the evaporation in the different seasons and months, because the proper elements are wanting. In regard to the meteorological year 1865–'66, we have the evaporation distributed in the following manner:

	Millimeters.
Winter	228.65
Spring	367.90
Summer	530.47
Autumn	327.36

that is to say, least in winter, greatest in summer, nearly equal in spring and autumn, being more restricted in the latter season, for reasons which will be easily perceived from the following table:

Seasons.	Temperature.	Humidity.	Force of the wind.
Winter	12.7	74.6	8.7
Spring	17.0	66.2	8.7
Summer	24.5	67.2	7.7
Autumn	19.8	70.6	5.8

For a first approximation, therefore, we may calculate the mean daily, monthly, and annual evaporation, as well as that for the seasons, by employing the coefficient only of the temperature, $t = 0.20675$. Thus, taking the mean monthly temperature derived from the observations of seventy-six years, we form the following table:

Months.	Mean temperature.	Daily evaporation as calculated.	Monthly evaporation as calculated.	Mean quantity of rain as observed.
		Millimeters.	*Millimeters.*	*Millimeters.*
January	+10.98	2.270	70.37	71.74
February	11.15	2.305	65.12	63.55
March	12.42	2.567	79.59	72.69
April	14.86	3.072	92.16	42.65
May	18.59	3.843	119.13	26.60
June	22.34	4.619	138.57	17.21
July	25.04	5.176	160.46	5.80
August	25.22	5.214	161.64	9.11
September	22.98	4.751	142.53	51.88
October	19.68	4.068	126.11	71.65
November	15.57	3.218	96.54	72.28
December	12.30	2.544	78.86	83.80

Hence, as regards seasons, the evaporation results as follows:

	Millimeters.
Winter	214.35
Spring	290.87
Summer	460.67
Autumn	365.18
Annual mean	1331.07

In regard to the water which fell, it will be seen that *in the months of January, February, March, and December, the evaporation was nearly equal; and that the annual evaporation was equal to twice and one-fourth the quantity of rain.*

THE GASPARIN EVAPORATOR.—With this atmometer the inconvenience constantly presents itself that, on days of rain, the indications point to erroneous results, through the impossibility of applying the

just correction for the water which falls, especially when there are very light showers, which cannot be measured by the pluviometer; whence the evaporation given by the Gasparin atmometer during the months when there has been rain will be always inferior to the reality. To have, therefore, the true ratio between the indications of the two atmometers, and to correct those of the Gasparin instrument, we proceed in the following manner: From the sums of evaporation, given by the two instruments in days when there was no rain, is deduced the ratio between the two evaporations for each month, and from the evaporation observed with the atmometer of Vivenot, on the days of rain, is derived, by means of the ratio, the corrections to be made in the indications of that of Gasparin.

In the following table will be found the monthly sums of this atmometer thus corrected, and which differ from those given in the single bulletins, because the aforesaid correction is then not applied. Hence, to determine a formula representing the evaporation according to the Gasparin atmometer, it is to be remembered that in this instrument the action of the force of the wind must needs be greater than for that of Vivenot, and that it is necessary, moreover, to take into account the direct action of the solar rays, as we have not the temperature of the water by that atmometer. We will suppose this action of the solar rays proportional to the sine of the meridian altitude of the sun, for the effect of the solar rays may be modified by the presence of clouds, diminishing that action whenever they interpose between the sun and station. On the other hand, the action of the daily temperature and the humidity will, for this instrument, be the same as for that of Vivenot; whence the coefficients relative to these two elements will remain the same. If, then, we calculate the part of the evaporation due to these two elements and subtract it from the daily evaporation of the Gasparin atmometer, the remainders of evaporation will be due to the direct action of the solar rays, the direct action of the wind, and the serenity. With these remainders will be established the equations of condition from which are to be found the coefficients, a, v, and f, relative to the sine of the meridian altitude of the sun, the serenity, and force of the wind.

In the table which follows will be found united all the necessary elements, that is to say, the mean value of the sine of the sun's altitude for every month, which we will denote by *sine h*, the volume of the clouds, the force of the wind, daily evaporation of the Gasparin instrument, the total for every month, by both the atmometers, and their relation; finally, the remainders of that of Gasparin, calculated as has been above stated.

Months.	Sin h.	Volume of clouds.	Force of wind.	Daily evaporation.	Total in the month.	Total evaporation, Vivenot.	Difference, G—V.	r
1865.				*Millimeters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*
May	0.945	38	7.4	5.753	178.33	105.21	1.695	2.528
June	0.967	28	11.2	7.074	212.21	141.58	1.313	3.145
July	0.958	15	9.7	7.977	247.30	159.08	1.554	3.538
August	0.911	11	6.9	7.490	232.18	164.01	1.416	2.913
September	0.816	24	9.2	6.002	180.06	128.92	1.397	2.149
October	0.682	50	10.9	3.524	109.32	85.13	1.284	0.439
November	0.548	55	9.0	2.751	82.54	83.73	0.986	0.482
December	0.478	61	8.0	1.928	59.78	66.69	0.896	0.531
1866.								
January	0.515	53	8.9	2.209	68.46	77.24	0.886	0.924
February	0.630	36	9.2	3.159	88.46	84.72	1.044	1.321
March	0.768	49	11.3	4.974	154.19	121.08	1.274	2.785
April	0.882	34	8.2	5.833	175.00	115.41	1.516	3.371
May	0.945	43	6.5	5.568	172.61	131.41	1.313	2.648
June	0.967	27	5.4	6.232	186.95	132.96	1.406	2.634
July	0.958	6	9.8	8.911	276.24	214.05	1.291	4.442
August	0.911	17	7.9	7.547	233.97	183.46	1.275	3.342
September	0.816	30	4.4	5.002	150.05	122.75	1.222	1.223
October	0.682	46	5.4	3.236	100.32	108.29	1.926	0.139
November	0.548	38	7.6	2.863	85.89	96.32	0.892	0.593
December	0.478	43	9.2	2.495	77.35	71.74	1.078	0.931

With the numbers of the 1st, 2d, 3d, and last columns are, formed twenty equations, which, treated by the method of least squares, yield the three following equations:

$$\left.\begin{aligned} 12.50\,.\,a+\ 503.18\,.\,v+\ 117.15\,.\,f-\ 34.75=0 \\ 503.18\,.\,a+29270.00\,.\,v+5883.60\,.\,f-1117.61=0 \\ 117.15\,.\,a+\ 5883.60\,.\,v+1449.90\,.\,f-\ 341.62=0 \end{aligned}\right\} \quad \cdots \quad (2)$$

These equations (2) being resolved, we find—

$$a=+2.9227;\ v=-0.0651;\ f=+0.2642$$

The signs of these coefficients agree with the considerations before stated, and the value of f, coefficient of the force of the wind, gives a result more than double that determined by the Vivenot atmometer, as we had supposed would be the case in the independent description of that instrument.

The daily evaporation of the Gasparin atmometer, indicated by E′, would be represented by the formula—

$$E'=T\,.\,0.20675-H\,.\,0.01517+F\,.\,0.2642-V\,.\,0.0651+(\sin h)\,.\,2.9227$$

where T is the daily mean temperature, H the humidity, F the force of the wind, V the quantity of the clouds expressed in hundredths of the sky obscured, and sin h the sine of the meridian-altitude of the sun. Calculated by this formula, we obtain the following results for the daily evaporations, which in the annexed table are placed beside those observed, as well as their relative differences:

Month.	1865.			1866.		
	Calculated.	Observed.	O—C.	Calculated.	Observed.	O—C.
	Millimeters.	*Millimeters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*	*Millimeters.*
January				1.689	2.209	+0.520
February				3.766	3.159	−0.607
March				4.327	4.974	+0.647
April				4.992	5.833	+0.841
May	5.460	5.753	+0.287	4.599	5.568	+0.969
June	7.890	7.074	−0.816	6.093	6.232	+0.139
July	8.823	7.977	−0.846	9.465	8.911	−0.554
August	8.345	7.490	−0.855	7.846	7.547	−0.299
September	7.105	6.002	−1.103	5.373	5.002	−0.371
October	4.701	3.524	−1.177	3.521	3.236	−0.285
November	2.666	2.751	+0.085	3.404	2.863	−0.541
December	0.935	1.928	+0.993	2.591	2.495	−0.096

From the differences it is seen that the results obtained by this instrument also are sufficiently exact to be capable of being approximately represented with the special formula, and the accord between the calculation and the observation seems to us satisfactory, regard being had to the construction and conditions of situation of this apparatus.

The daily mean thus calculated from the elements of the twenty months gives a result equal to $5^{mm}.156$, while the observed mean was $5^{mm}.027$; whence we have the difference, $0^{mm}.129$, so that the total evaporation as calculated for the twenty months is found to be equal to $3{,}145^{mm}.16$, and the sum of the evaporation observed $3{,}071^{mm}.21$—difference, $73^{mm}.95$.

The daily mean, as calculated for 1866, gives a result of $4^{mm}.7852$, and the total in the twelve months, $1{,}746^{mm}.60$, while the observed was $1{,}769^{mm}.49$—difference, $22^{mm}.89$.

Knowing, therefore, the mean force of the wind, the mean humidity, and at the same time the clearness and temperature, we shall be in a position to verify approximately the mean monthly and annual evaporation by this atmometer exposed to the direct action of the wind and rays of the sun. We have not all these elements, and hence cannot at present apply the formula in its entirety. But, for a first approximation, we may take account solely of the temperature, humidity, and altitude of the sun, having the coefficients of the force of the wind and volume of the clouds contrary signs; in effect, thus calculated the evaporation for 1866 results differently from that observed, which was $1{,}769^{mm}.0$ by only $56^{mm}.0$.

By making the calculation, with the relative humidity transcribed from the only decennium in which psychrometrical observations were conducted, the evaporation in the open air yields the results denoted in the following table, as well for the daily mean as for the total of each month and each season, together with the annual mean:

Months.	Mean temperature.	Mean humidity.	Sin *h*.	Daily evaporation.	Monthly evaporation.	By seasons.	
January	+10.98	78.7	0.515	2.595	80.45	Winter	249.32
February	11.15	77.7	0.630	2.982	84.24		
March	12.42	77.2	0.768	3.654	113.27		
April	14.86	76.1	0.882	4.508	135.24	Spring	419.07
May	18.59	73.5	0.945	5.502	170.56		
June	22.34	72.0	0.967	6.366	190.98		
July	25.04	70.1	0.958	6.925	114.68	Summer	617.64
August	25.22	69.3	0.911	6.838	211.98		
September	22.98	73.5	0.816	6.034	181.02		
October	19.68	75.7	0.682	4.926	152.71	Autumn	444.19
November	15.57	75.9	0.548	3.682	110.46		
December	12.30	80.7	0.478	2.730	84.63	Annual mean	1,730.22

In relation to rain, by comparing the total monthly evaporations with the mean quantity of water which falls in each month, and which will be found recorded in one of the preceding tables, it will be seen that the *evaporation according to the Gasparin apparatus is about equal to the rain only in the months of January and December, being always greater in the other months; the annual evaporation is very nearly thrice the height of the water which falls, and equal to once and a third of that in the shade, or as denoted by the atmometer of Vivenot.* From the quantities of the monthly evaporation calculated after both instruments let us take the differences referable to the different positions of the atmometers, and transcribe them in connection with those actually verified in 1866. G—V indicates the Gasparin evaporation less that of the Vivenot atmometer.

Differences.

	G—V from calculation.	G—V observed in 1866.
	Millimeters.	Millimeters.
January	+10.08	— 8.78
February	+19.12	+ 3.74
March	+33.69	+33.11
April	+43.08	+59.59
May	+51.43	+41.20
June	+52.41	+53.99
July	+54.22	+62.19
August	+50.34	+50.51
September	+38.49	+27.30
October	+26.60	— 7.97
November	+13.92	—10.43
December	+ 5.77	+ 5.61

The above differences, if we consider the disturbances to which the Gasparin atmometer is exposed from rain and clouds, discover a suffi-

cient agreement, and at the same time show that these differences increase from January till the month of July, and then diminish until December, in which occurs the minimum of difference for the two instruments.

In calculating the evaporation by day and that by night for each month, we have found the following numbers:

Months.	Evaporation.		
	By day.	By night.	Ratio.
	Millimeters.	Millimeters.	Millimeters.
January	1.96	0.64	3.06
February	2.35	0.63	3.73
March	2.95	0.70	4.21
April	3.64	0.87	4.18
May	4.38	1.12	3.91
June	4.99	1.38	3.62
July	5.30	1.63	3.25
August	5.02	1.82	2.76
September	4.27	1.76	2.43
October	3.26	1.67	1.95
November	2.48	1.20	2.07
December	1.93	0.80	2.41

Thus the greatest evaporation at night occurs in the month of August, the least in February; the ratio between that of day and night increases from October to March, and then diminishes gradually till October.

From what we have thus been able to compile it would evidently seem that for a complete study of the subject of evaporation it is indispensable to have two atmometers, one to be stationed with the other meteorological instruments, and defended from the direct action of the wind and rays of the sun, the other entirely free. For the latter purpose the construction of the Gasparin atmometer is suited, for the former that of Vivenot, though it might be expedient to give to this last greater dimensions than those heretofore employed.

ON THE ELECTRICITY OF INDUCTION IN THE AERIAL STRATA OF THE ATMOSPHERE WHICH, IN THE SHAPE OF A RING, SURROUND A CLOUD THAT IS RESOLVING INTO RAIN, SNOW, OR HAIL.

By Professor Fr. Zantedeschi,
Of the Royal Venetian Institute of Sciences, Letters and Arts.

[Extracted from Vol. XII, series III, of the Transactions of the Institute.]

Professor Luigi Palmieri states as follows:

"Where rain is falling there must be present positive electricity, with a zone or wave of negative electricity on every side, which zone, in tempestuous weather, may extend to a distance of thirty miles, especially in summer. Upon this subject, after so many observations, conducted by

precise methods and under favorable circumstances, I feel at liberty to deny the free negative electricity of a serene sky, and also the existence of clouds endowed, as a property, with this electricity, maintaining that the negative electricity only manifests itself with the falling of the rain, hail, or snow, through the effect of the influence of the positive electricity, which is copiously developed on the resolution of the clouds into water. I deem it useless to explain how negative electricity may also be present when rain falls on the place of the observations, for this indicates another more intense rain which is proceeding at a certain distance."*

The Rev. Padre A. Secchi shows that he holds the same doctrine, for he says:

"In regard to the fact asserted by Professor Palmieri that negative electricity is not present in a serene state of the sky, except in the case of rain actually falling on the spot, or at least at some distance off and in view of the horizon, I have found it to be constantly verified."

He also recognizes a primary negative zone, which attends a storm through the effect of induction.†

The opinion of Professor Palmieri, thus sustained by Rev. Padre A. Secchi, is wanting in point of positive proof. It would be necessary, in order to supply such proof, that an experimenter should be stationed at the center where the cloud which is being resolved into rain is directly superincumbent, and should investigate the kind of electricity of the falling shower; while other experimenters should be placed around its periphery, so as to form a ring, each of whom should explore the nature of the electricity of the air surrounding the dissolving cloud. By a complete experiment like this, the problem propounded by Professor Palmieri might be solved. The rain falling at the center, endued with positive electricity or with negative electricity, should be found to have around it a circle of negative electricity or of positive electricity.

I requested Padre A. Secchi to make this experiment in the environs of Rome, but he assured me that it could not be carried into effect there on account of the topographic difficulties of the hills which encompass that city. Not being myself able to prosecute the experiment on a large scale in the Euganean region and the circumjacent cities of Vicenza, Lignano, Badia, Rovigo, and Padua, I limited my views to a cabinet experiment, which, nevertheless, appears to me sufficient for the solution of the proposed problem. I suspended to a thread of silk a hollow sphere of brass, which I proceeded to electrify now positively and again negatively. Arranging around it the wire of a straw electrometer and bringing it successively nearer to the electrified sphere, I

* *Bolletino meteorologico dell' Osservatorio del Collegio Romano*, Vol. II, No. 15, p. 113, for the year 1863: Letter from Signor L. Palmieri, director of the *Osservatorio Vesuriano*, to Padre A. Secchi.

† *Bolletino meteorologico dell' Osservatorio del Collegio Romano*, Vol. II, No. 17, p. 129, for 1863: Reflections of Professor Francesco Zantedeschi on the article of Padre A, Secchi, entitled: *Altie studii di elettricita atmospherica.*

enabled by all those causes to note the passage from one phase to the other. Such is the origin of every phenomenon previously observed. After having established this law by many personal observations, I did not fail to seek for its corroboration in the records of the observations of others; and many facts mentioned by Beccaria seemed to me derived from that law, which is otherwise corroborated in a description of a fall of hail observed by Oward. Quetelet, upon hearing of this law, examined the records of his own observations, and found it corroborated by them; and he then proclaimed it also, taking my observations into account, but not giving me clearly the priority of discovery that undoubtedly belonged to me. Afterward others confirmed said law, which I never failed to verify whenever opportunity offered, the best conditions being to have a very extensive horizon and a rain or storm commencing at a considerable distance from the observer, approaching him with the wind, and then leaving him behind. These are, in fact, the only conditions in which it is possible to verify the truth of the above-mentioned law.

On the 20th of September, 1868, on or about 11 o'clock a. m., there appeared above the sea, in a westerly direction, somewhere beyond the Ponzie Islands, a cloud of very small dimensions. Suspecting a storm, I used the apparatus with movable conductor, and noticed a strongly positive tension, indicating a distant rain; and suspending the conductor in an elevated position, the oscillations of the gold plates of Bohnenberger's electroscope indicated lightning. The wind was very weak and coming from southwest, bringing the storm toward the observatory.

At noon the tension became negative, and after a few moments, during which it was null, and when already could be heard the thunder-claps of the approaching storm, the negative tension increased so as to emit sparks; thunder was heard more distinctly, and rain was seen falling on the Campania. At 1 o'clock p. m. rain was falling upon the observatory, and the tension, passing through 0, became positive. At 3 p. m. rain had ceased to fall on the observatory, but was falling over Castellamare, giving again a strong negative tension. Over the Mounts of Castellamare it ceased to rain, and positive electricity returned, but with a weak tension of 15°. Had the storm kept on its primary course east of the observatory, there should have been a strong positive tension ($+\infty$). In this case, therefore, the last phase alone failed to be observed.

Whoever found himself in elevated places, or upon the open sea, must have often noticed two or more rains, each distinct from the other, falling with small intervals between them; and this explains why apparent exceptions are often recorded against the universality of the law. Let us suppose, for instance, that on the spot where is the observer a rain is falling, while another, stronger, falls at some distance; then it becomes evident that, if positive and negative electricity were to be obtained from the first stronger than from the second, with the rain falling upon the observatory, there should be in it negative electricity. And this is

the origin of the assumed negative rains, as well as of the supposed negative clouds, two errors as yet taught by some authorities. After twenty years of study of electrical meteorology, I believe I have acquired the right to reject many errors, without caring about the names of those by whom those errors were accredited. But, giving a proper interpretation to the facts recorded by diligent and eminent observers, instead of objections to the truth of the principle I have exposed, we discover in them the proof of what I have said. Many, for instance, upon the authority of Beccaria, affirm the production of electricity in pure atmosphere, (*ciel sereno*,) and I have demonstrated that this can only take place when, at some distance from the place of observation, rain, hail, or snow is falling. Now, by a careful perusal of the illustrious electrician's works, we see that, instead of a refutation of my principle, there is in them what might entitle him to the right of priority in the discovery. The following passage from Beccaria's works seems quite clear: "*Electricity in pure atmosphere is always in excess, and whenever in serene atmosphere electricity in defect is observed, it has been carried there by wind from some part of the atmosphere, as distant as it might be, where there are actually clouds, snow, rain, or hail.*" It is evident that the diligent observer derives the electricity in such case from a distant region, not serene, and, instead of the influx, believes it to be carried by the wind; but the fact of electricity becoming negative after the storm had passed the place of observation, and was carried eastward by a gentle wind, as previously described, would be sufficient to preclude the idea of the wind as carrier of negative electricity, even had I not observed, a hundred times, electricity with the most perfect calm. Suppressing, therefore, the word cloud in Beccaria's sentence above reproduced, it will remain a fact that negative electricity in serene atmosphere is obtained only when, at a distance from the place of observation, rain, hail, or snow is falling.

Peltier had observed negative electricity in presence of certain clouds of a dark-bluish color, and thought that their electrical nature might be made known by their color. When clouds at a distance resolve themselves in rain they exactly assume that color described by the French physicist, and the falling rain produces negative electricity. Thus my observations are confirmed, not refuted.

The existence of clouds loaded with negative electricity pertaining to them has been attributed either to the negative electricity often observed with a fall of rain at the place of observation, or to the same electricity observed in presence of clouds. We have explained how the first is produced; the second is a certain sign of distant rain. On the Vesuvius Observatory clouds often pass in such a way as to surround the whole building; yet in many years of continued observations, with fixed and movable conductors, I have never met, under those conditions, with negative electricity.

CLIMATE OF KANSAS.

By R. S. Elliott,

Industrial agent Kansas Pacific Railway.

Pond Creek Station, Kansas Pacific Railway,
September 22, 1870.

I have been on the Plains nearly all the time from early in May till this date. There has been much dry weather, but I have not seen one cloudless day; no day on which the sun would rise clear and roll along a canopy of brass to the west. There has always been humidity enough to form clouds at the proper height, and on many days they would be seen defining, by thin flat bottoms, the exact line where the condensation became sufficient to render the vapor visible. The sun would be only partially obscured at intervals, the condensation not being of a character materially to lessen the effect of his rays in giving us heat and light, until in the after part of the day, when appearances of a storm were apt to present themselves in some part of the heavens; only, however, too often to pass away without giving us the desired shower.

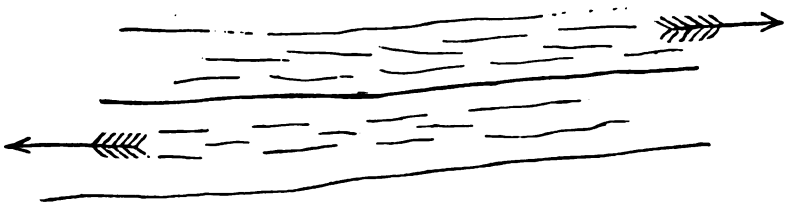
I conclude from all this that abundant moisture has floated over the Plains to have given us a great deal more rain than would be desirable if it had been precipitated.

Sometimes a storm would be seen to gather near the horizon, and we could see the rain pending from the clouds like a fringe, hanging apparently in mid-air, unable to reach the expectant earth. The rain stage of condensation had been reached above, but the descending shower was revaporized apparently, and thus arrested.

In a moderately calm day—for our calms are only *moderate* in this airy region—I have observed little columns of dust to arise in all directions, generally widely scattered. These usually, if not always, coincided with mirage in all directions; not that they appeared in the mirage, but coincided in the day of their appearance. The mirage, however, very often appeared on days too windy for the little columns to be formed; they being only whirlwinds rendered visible by the dust taken up. Within forty-eight hours after the little column phenomena, I have noted that the wind is apt to be coming strongly from the northward, laden with a mist or scud that sometimes reaches the dignity of rain.

The changes of wind are often very sudden, from southward—the prevailing point in summer—to all points, but mainly to the north. Sometimes this change is observed during the progress of a rain-storm, and *seems* to be due to a sort of local or limited cyclone; but the difference in temperature between the south and north winds seems to forbid the cyclone theory. I cannot understand how a circuit of a few hundred miles in the heated prairie should so cool a current that had only

whirled by us a very short time before. If we reject the cyclone theory we must suppose parallel but opposite currents, in streaks, thus:



On 15th July last I witnessed a fine example of this sudden change of direction and temperature in the wind. A storm arose, with lightning in the west, the southwest, and the northwest. The railway train was going eastward at the distance of about three hundred and twenty-five miles west from Kansas City. We were soon enveloped in the storm, rain, and wind so strong from the north that the wheels of the coaches could be felt grating their flanges on the south rail, and the rain, striking the end windows of the car, ran across in a true horizontal line. In a few minutes the temperature had fallen so low as to be uncomfortable; but in a run of not, I think, over ten miles, we were again in the *warm* winds usual at that season, and these, by contrast, seemed to be the *hot* winds sometimes experienced.

These hot winds are not, so far as I have observed, apt to be constant in one place for any considerable length of time; they strike your face suddenly, and in perhaps a minute are gone. They seem to run along in streaks, or *ovenfulls*, with the winds of ordinary (but rather high) temperature. They do not begin, I believe, till in July, as a general rule, and are over by September 1, or perhaps by August 15. Their origin I take to be, of course, in heated regions south or southwest of us; but their peculiar occurrence, so capricious and often so brief, I cannot explain to myself satisfactorily.

I have no rain-gauge record at hand for this and past seasons; but I may remark that this season, since about 15th of July, in these distant plains, has given us rain enough to make beautifully verdant the spots in the prairie burned off during the "heated term" of July. From Kit Carson eastward the rains have been, I think, exceptionally abundant. All through the summer we have had dew occasionally; and it has been remarked that buffalo meat has been more difficult of preservation than heretofore; facts indicative of humidity in the atmosphere, even when but little rain-fall was witnessed. Turnips sown in August would have made a crop, without irrigation, in this vicinity, four hundred and twenty-two miles west of the State line of Missouri, and about three thousand two hundred feet above the sea-level.

Facts such as these seem to sustain the popular persuasion in Kansas, that a climatic change is taking place, promoted by the spread of settlements westwardly; breaking up portions of the prairie-soil; covering the earth with plants that shade the ground more than the short grasses,

thus checking or modifying the reflection of heat from the earth's surface, &c. The fact is also noted that even where the prairie soil is not disturbed, the short buffalo-grass disappears as the "frontier" extends westward, and its place is taken by grasses and other herbage of taller growth. That this change of the clothing of the Plains, if sufficiently extensive, might have a modifying influence on the climate, I do not doubt; but whether the change has been already spread over a large enough area, and whether our apparently or really wetter seasons may not be only part of a cycle, are unsettled questions.

The civil engineers of this railway believe that the rains and humidity of the Plains have increased during the extension of the railroads and telegraphs across them. If this is the case, it may be that the mysterious electrical influence in which they seem to have faith, but do not profess to explain, has exercised a beneficial influence. What effect, if any, the digging and grading, the iron rails, the tension of steam in locomotives, the friction of metallic surfaces, the poles and wires, the action of batteries, &c., could possibly or probably have on the electrical conditions, as connected with the phenomena of precipitation, I do not, of course, undertake to say. It may be that wet seasons have merely happened to coincide with railroads and telegraphs. It is to be observed that the poles of the telegraph are quite frequently destroyed by lightning; and it is probable that the lightning thus discharges in many places where before the erection of the telegraph it was not apt to do so, and perhaps would not reach the earth at all.

I trespass on your attention with these crude remarks, not knowing but what I might possibly lead your thought to something of value in connection with meteorological phenomena in this distant but interesting region. You will readily see that I have no claim to the possession of meteorological knowledge, in the higher sense of the term.

I may state that during the past season, from April to July, wheat was grown and matured, *without irrigation*, at a point on the Plains three hundred and seventy-six miles west of Kansas City, and two thousand nine hundred and forty-eight feet above the sea. A sample has been sent to the Department of Agriculture. This wheat, about meridian 101, sustains the views of the article I took the liberty of sending you in March last on the "Climate of the Plains."

ACCOUNT OF A HAIL-STORM ON THE BOSPHORUS.

From Porter's (Commodore) Constantinople, 1835, Vol. I, pp. 43–47.

[Our attention has been called to the following account of a remarkable hail-storm, published in the letters of the late Commodore Porter, of the United States Navy, a work now out of print and not likely to meet the eye of meteorologists.—J. H.]

On our way from the residence of the minister to meet the Reis Effendi, at Candalie, half way between this and Constantinople, and a few minutes after leaving the landing, I witnessed a scene the most awful and appalling that the imagination can depict.

In a six-oared kaick, the American minister, his secretary, &c., and myself, with his kervoss, started with the treaty and regalia of about thirty thousand dollars worth of snuff-boxes, which you might have put in your coat pocket. We had got perhaps a mile and a half on our way, when a cloud rising in the west gave indication of an approaching rain. In a few minutes we discovered something falling from the heavens with a heavy splash, and of a whitish appearance. I could not conceive what it was, but observing some gulls near, I supposed them to be darting for fish; but soon after discovered that they were large balls of ice falling. Immediately we heard a sound like rumbling thunder, or ten thousand carriages rolling furiously over the pavement. The whole Bosphorus was in a foam, as though heaven's artillery had been discharged upon us and our frail machine. Our fate seemed inevitable; our umbrellas were raised to protect us; the lumps of ice stripped them into ribands. We fortunately had a bullock's hide in the boat, under which we crawled and saved ourselves from further injury. One man, of the three oarsmen, had his hand literally smashed; another much injured in the shoulder; Mr. H. received a severe blow in the leg; my right hand was somewhat disabled, and all more or less injured.

A smaller kaick accompanied, with my two servants. They were both disabled, and are now in bed with their wounds; the kaick was terribly bruised. It was the most awful and terrific scene that I ever witnessed, and God forbid that I should ever be exposed to such another. Balls of ice as large as my two fists fell into the boat, and some of them came with such violence as certainly to have broken an arm or a leg, had they struck us in those parts. One of them struck the blade of an oar and split it. The scene lasted, may be, five minutes; but it was five minutes of the most awful feeling that I ever experienced. When it passed over we found the surrounding hills covered with masses of ice, I cannot call it hail; the trees stripped of their leaves and limbs,

and everything looking desolate. We proceeded on our course, however, and arrived at our destination drenched and awe-struck. The ruin had not extended so far as Candalie, and it was difficult to make them comprehend the cause of the nervous and agitated condition in which we arrived; the Reis Effendi asked me if I was ever so agitated when in action? I answered no, for then I had something to excite me, and human means only to oppose. He asked the minister if he was ever so affected in a gale of wind at sea. He answered no, for then he could exercise his skill to disarm or render harmless the elements. He asked him why he should be so affected now. He replied, "From the awful idea of being crushed to death by the hand of God with stones from heaven, when resistance would be vain, and when it would be impious to be brave." He clasped his hands, raised his eyes to heaven, and exclaimed, "God is great!"

Up to this hour, late in the afternoon, I have not recovered my composure; my nerves are so affected as scarcely to be able to hold my pen or communicate my ideas. The scene was awful beyond all description. I have witnessed repeated earthquakes, the lightning has played, as it were, about my head; the wind roared, and the waves have at one moment thrown me to the sky, and the next have sunk me into a deep abyss. I have been in action, and have seen death and destruction around me in every shape of horror; but I never before had the feeling of awe which seized upon me on this occasion, and still haunts, and I feel will ever haunt me. I returned to the beautiful village of Buyucdenè. The sun was out in all its splendor; at a distance all looked smiling and charming, but a nearer approach discovered roofs covered with workmen repairing the broken tiles; desolate vineyards, and shattered windows. My porter, the boldest of my family, who had ventured an instant from the door, had been knocked down by a hailstone, and had they not dragged him in by the heels would have been battered to death. Of a flock of geese in front of our house, six were killed, and the rest dreadfully mangled. Two boatmen were killed in the upper part of the village, and I have heard of broken bones in abundance. Many of the thick brick tiles with which my roof is covered are smashed to atoms, and my house was inundated by the rain that succeeded this visitation. It is impossible to convey an idea of what it was. Imagine to yourself, however, the heavens suddenly frozen over, and as suddenly broken to pieces in irregular masses, of from half a pound to a pound weight, and precipitated to the earth. My own servants weighed several pieces of three-quarters of a pound, and many were found by others of upward of a pound. There were many which fell around the boat in which I was that appeared to me to be as large as the swell of the large-sized water decanter. I have heard of a stout tree in my neighborhood, into the crotch of which a mass of ice fell which split the tree as though it had been riven by a wedge of iron.

ACCOUNT OF A HAIL-STORM IN TEXAS.

By Lieutenant George M. Bache, U. S. A.

One of those terrific hail-storms often heard of, but seldom experienced, visited this city last evening.* Captain A., Doctor B., and myself were returning from a day's fishing some ten miles from San Antonio, in an army ambulance, about 7 p. m., when we first noticed indications of rain. Dark clouds were rising in the northwest, accompanied with a great deal of what we at first supposed to be heat lightning. This gradually became more vivid, the clouds blacker, the thunder began to make itself heard, and our first supposition of a light shower changed to a certain prospect of a severe storm.

The mules were put to their most rapid gait, with the hope of reaching town before the tempest assailed us, but to no purpose; it broke on us when we were about two miles from home. A fierce wind from about due north, driving sheets of rain right in our faces, put a stop to any further progress, and compelled us to turn the ambulance from the direction of the storm into the "mesquite" bushes, where we prepared ourselves to quietly sit and take the result. Suddenly, however, something struck the side of the ambulance, with a noise similar to that of a stone violently thrown—another, and another—and now we hear the resounding thuds on the bodies of the mules, and the war of the elements has commenced in earnest. Neither mule nor man was prepared for this, and the former, beaten to infuriation, dashed off wildly into the mesquite bushes. It was impossible to see, and, fearing a capsize and a drag in the chaparral, we jumped out, still not realizing what was upon us; for all this had happened in a few moments of time.

Continuous blows on the head, body, and legs soon enabled us to realize the serious nature of our condition. Stones of ice of all shapes and of the size of the fist, cut and bruised our bodies, and with our arms crossed above our heads we rushed to secure the slight protection of a mesquite bush, there being no trees on the prairie. We were each at different times knocked down by blows about the head; one of us, Captain A., three times. Cut, bleeding, bruised, and still with no prospect of abatement, not knowing how long such a phenomenon might last, nor how soon we might be rendered senseless, we felt our situation as by no means enviable.

In the mean time, the mules, which having again headed the storm in their fury were nearly stunned by repeated blows on the head and sides,

* May 10, 1868.

came near us, being driven before the storm, but too much weakened to move rapidly. We took advantage of this and leaped into the ambulance, choosing the lesser evil. Providentially the wheels of the carriage became locked in a rail fence, and the mules were too much exhausted to do any more running. We put the seats over our heads, and thus protected, drenched, shivering with cold, and continually beaten on the legs and sides, we awaited the subsidence of the storm. The falling of the hail lasted twenty-two minutes, commencing at half past eight p. m. It was accompanied with heavy rain, bright blinding flashes of lightning, and a continuous roar, varied with sharp crashes, of thunder. The rain ceased with the hail, but fell very heavily again during the night, causing a rise of nearly twenty feet in the San Antonio river. The curtains of our ambulance were cut to ribbons, and we scarcely thought the mules would live through the tempest, but they did, and, though much bruised and stunned, brought us safely to town. With black eyes, bloody heads, smashed hats, bruised arms, and torn and muddy clothes, we appeared as if we had just come from a free fight and had been very badly used. Indeed, experience only could have convinced us that any one could have endured exposure to such a violent storm and lived.

We found our house flooded with water, and all the window panes and venetian blinds on its north side smashed to pieces. Persons who were in the house describe the noise of the hail as it struck the roof and sides as exceedingly terrific. The next morning the town presented the appearance of a bombarded city. The houses appeared as if thousands of shots had been fired against their walls and roofs at point-blank range. The walls of our house, covered with an inch thickness of plaster on the outside, show, as in the inclosed photograph, the innumerable dents made by the hail. Shingle roofs were broken by the hail and scattered in pieces by the wind. Large holes were cut through tin roofs and gutters. Several houses were entirely unroofed; among others, that of General Mason, who, with his family, took refuge in a doorway. The walls of an old church were blown down and its roof deposited in the street. Trees, in some instances, were torn up by the roots, and in others thrown down. In one case a hail-stone penetrated the roof of a house and did not spend its force until it reached the floor. The trees and bushes were entirely stripped of their foliage, and small branches cut off. The Indian corn was cut down as if with a scythe, and vegetables and flowers beaten into the ground. The largest authenticated stone that I have heard of weighed two pounds, though there are various reports of five and six-pounders. The stones probably averaged from four to eight ounces, and were of the size of the fist and upwards. The very large ones, of two pounds and thereabouts, must have been few and far between, as nothing could have withstood them. They were irregular in shape, as if, in their descent, many had been frozen together and thus formed one mass as hard as rock.

A woman who, with her husband, had camped out on the prairie, had two ribs broken, and was thought to be fatally injured. A dog was killed outright; and there are numerous cases of cuts and bruises, more or less severe. There are also reports of fatal casualties to human life in the vicinity, which have not yet been authenticated. The momentum of the hail-stones is shown by the fact, as witnessed by myself, of a hole about four inches in diameter through both sides of a sheet-iron stove-pipe which rose from the roof of a small out-house in the garden and did service as a chimney. Boards of fences were knocked off and split in pieces, and trees barked as if by cannon balls. I think the storm of hail not to have extended over a path of more than two miles in width. We hear of the storm having visited other places, but having no communication, save by stages and a semi-weekly paper, we have not yet learned its course. The hail came down at an angle of about 30° from the horizontal, and lowered the temperature from 90° to 64° Fahrenheit. The day had been close and sultry. The temperature again rose after the storm, and the stones on the ground were soon melted.

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